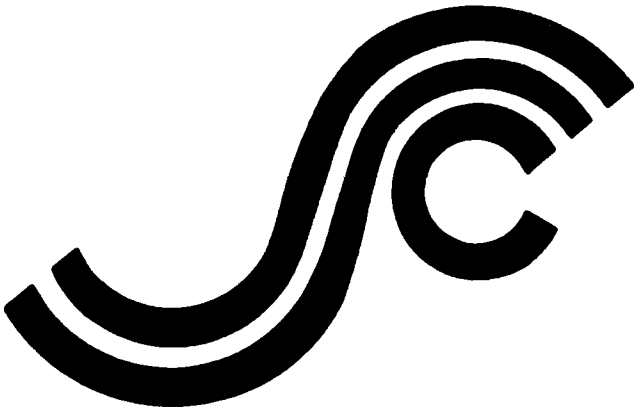
SSC-339

ICE LOADS AND SHIP RESPONSE TO ICE

A SECOND SEASON



SHIP STRUCTURE COMMITTEE

1990

SHIP STRUCTURE COMMITTEE

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An Interagency Advisory Committee
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Address Correspondence to:

Secretary, Ship Structure Committee
U.S. Coast Guard (G-MTH)
2100 Second Street S.W.
Washington, D.C. 20593-0001
PH: (202) 267-0003
FAX: (202) 267-0025

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ICE LOADS AND SHIP RESPONSE TO ICE
A SECOND SEASON

This report is the second in a series of six that address ice loads, ice forces, and ship response to ice. The objective of this research is to develop ice load criteria for the design of ships. The data for these reports were obtained during deployments of the U.S. Coast Guard Icebreaker POLAR SEA. The first report in this series, published as SSC-329, contained an analysis of data from a single ice season. This report presents the results from a second season of ice breaking and includes a final analysis of local ice load measurements from four deployments. The other reports address global ice impact forces, hull strain and impact force time histories, and ice ramming forces. They are published as SSC-340 through SSC-343.

J. D. SIPES
Rear Admiral, U.S. Coast Guard
Chairman, Ship Structure Committee

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16. Abstract

This report presents the results and final analysis of the local ice load measurement conducted on four deployments aboard the USCGC POLAR SEA between 1982-84. Data were collected in first year and multiyear ice in the Bering, Chukchi, and Beaufort Seas and first year level ice in McMurdo Sound, Antarctica. The first and second deployment results from trips to the Alaskan Arctic as well as the instrumentation and data analysis techniques were presented in "Ice Loads and Ship Response to Ice" (SSC-329) (Reference 1). The third deployment results from the Antarctic were presented in a report to the Maritime Administration (Reference 2). The intent of this report is to present the data collected in the Beaufort Sea in the summer of 1984 (the fourth data collection program presented in Volume I), to summarize the previous three data collection programs and to provide the final analysis of all data as a whole (Volume II).

The objective of the most recent data collection effort (Beaufort Summer 84), was to gather additional data in heavy first year and multi-year ice in the Beaufort and North Chukchi Seas. A total of 337 events were analyzed of which 32 are known multi-year ice impacts. Level ice conditions varied in thickness from 2 to 3 ft (.6 to .9 m) and pressure ridges were transitted with sail heights as high as 8 ft (2.4 m). Speeds of advance during impacts varied from less than 1 kt to 7.5 kts (0.5 to 3.9 MPS).

The highest single subpanel pressure measured was 1041 psi (7.2. MPa) and the highest peak force measured was 374 LT (380 MT). These values are about 25% smaller than the peak values for multi-year ice impacts measured on previous deployments.

A statistical analysis of extreme pressures and forces was performed for the data collected on all four deployments and is presented in Volume II. Pressures over one subpanel, four subpanels, and total forces were fitted to 3 parameter extreme value distributions. The results of the statistical analysis were then used to suggest ice load criteria in support of icebreaking ship design and hull design regulations for icebreaking ships.

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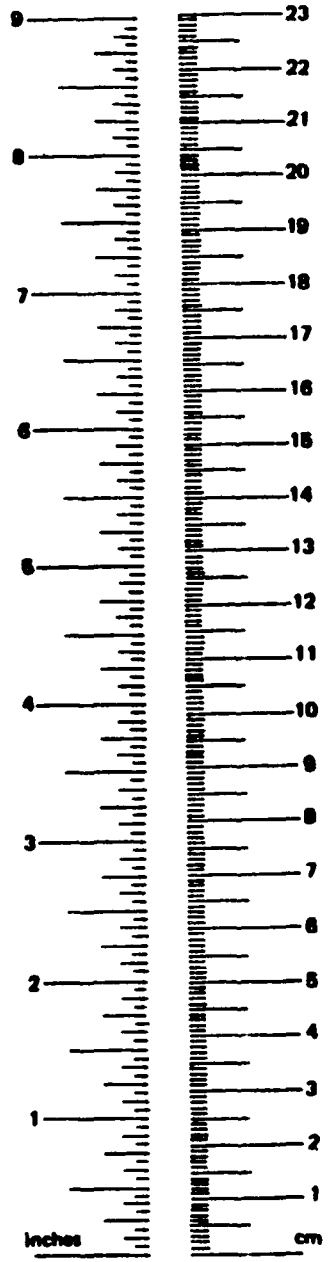
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

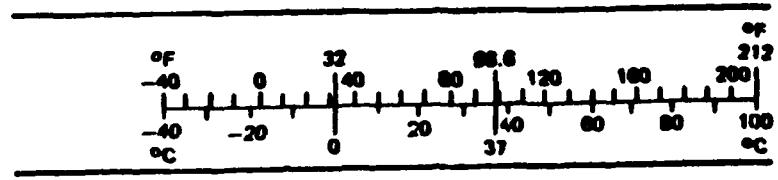
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.96	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286, Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This report presents the results and final analysis of the local ice load measurement conducted on four deployments aboard the USCGC POLAR SEA between 1982-84. Data were collected in first year and multiyear ice in the Bering, Chukchi, and Beaufort Seas and first year level ice in McMurdo Sound, Antarctica. The first and second deployment results from trips to the Alaskan Arctic as well as the instrumentation and data analysis techniques were presented in "Ice Loads and Ship Response to Ice" (SSC-329) (Reference 1). The third deployment results from the Antarctic were presented in a report to the Maritime Administration (Reference 2). The intent of this report is to present the data collected in the Beaufort Sea in the summer of 1984 (the fourth data collection program presented in Volume I), to summarize the previous three data collection programs and to provide the final analysis of all data as a whole (Volume II).

The objective of the most recent data collection effort (Beaufort Summer 84) reported herein, was to gather additional data in heavy first year and multi-year ice in the Beaufort and North Chukchi Seas. A total of 337 events were analyzed of which 32 are known multi-year ice impacts. Level ice conditions varied in thickness from 2 to 3 ft (.6 to .9 m) and pressure ridges were transitted with sail heights as high as 8 ft (2.4 m). Speeds of advance during impacts varied from less than 1 kt to 7.5 kts (0.5 to 3.9 MPS).

The highest single subpanel pressure measured was 1041 psi (7.2. MPa) and the highest peak force measured was 374 LT (380 MT). These values are about 25% smaller than the peak values for multi-year ice impacts measured on previous deployments.

Extreme value analysis of the pressure and force data was performed for the data collected on all four deployments and is presented in Volume II. Pressures over one subpanel, four subpanels, and total forces were fitted to 3 parameter extreme value distributions. The results of the extreme value statistics performed were then used to suggest ice load criteria in support of icebreaking ship design and hull design regulations for icebreaking ships.

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1.0 INTRODUCTION

In 1982, USCGC POLAR SEA was instrumented with an array of strain gages on the port bow for the purpose of measuring ice impact pressures. Two trips to the Alaskan Arctic were made in October of 1982 and in March-April 1983 during which time about 1400 impact events were collected. The research was carried out on behalf of the Interagency Ship Structures Committee, the U.S. Maritime Administration, and Transport Canada (Transportation Development Centre). Work was performed in conjunction with environmental data collection programs sponsored by the Alaskan Oil and Gas Association and the U.S. Maritime Administration.

Ten cant frames (CF 35 to CF 44) were instrumented at 8 vertical locations by strain gauging the webs of the frames in compression perpendicular to the shell plating (Figure 1.1). A total of sixty active channels of strain gauges allowed contact pressures over an area of up to 98 ft^2 (9.1 m^2) to be measured. An individual strain gauge channel was related to an area of 1.63 ft^2 (.15 m^2) for which a uniform pressure was computed for a measured strain. A complete description of the data acquisition system and the data reduction procedures as well as the results of the two deployments can be found in Reference [1]*.

The POLAR SEA's trip to the Antarctic in January 1984 offered a third opportunity to collect ice impact data in thick level ice in conjunction with resistance tests sponsored by the Maritime Administration (MARAD), Naval Engineering Division of U.S. Coast Guard and Canadian Transportion Development Centre (TDC). An additional 310 ice impact events were collected by this effort and are reported under contracts to MARAD [2] and TDC [3].

A fourth data collection program was conducted in October and November of 1984, termed the 1984 Summer Deployment, to gather additional data in summer multiyear ice conditions where the highest loads could be expected. This deployment recorded 337 impact events which are presented and analyzed in Volume I. Volume II summarizes data from all four deployments and presents further analysis of the complete data set.

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* Numbers in brackets refer to references listed in Section 6.

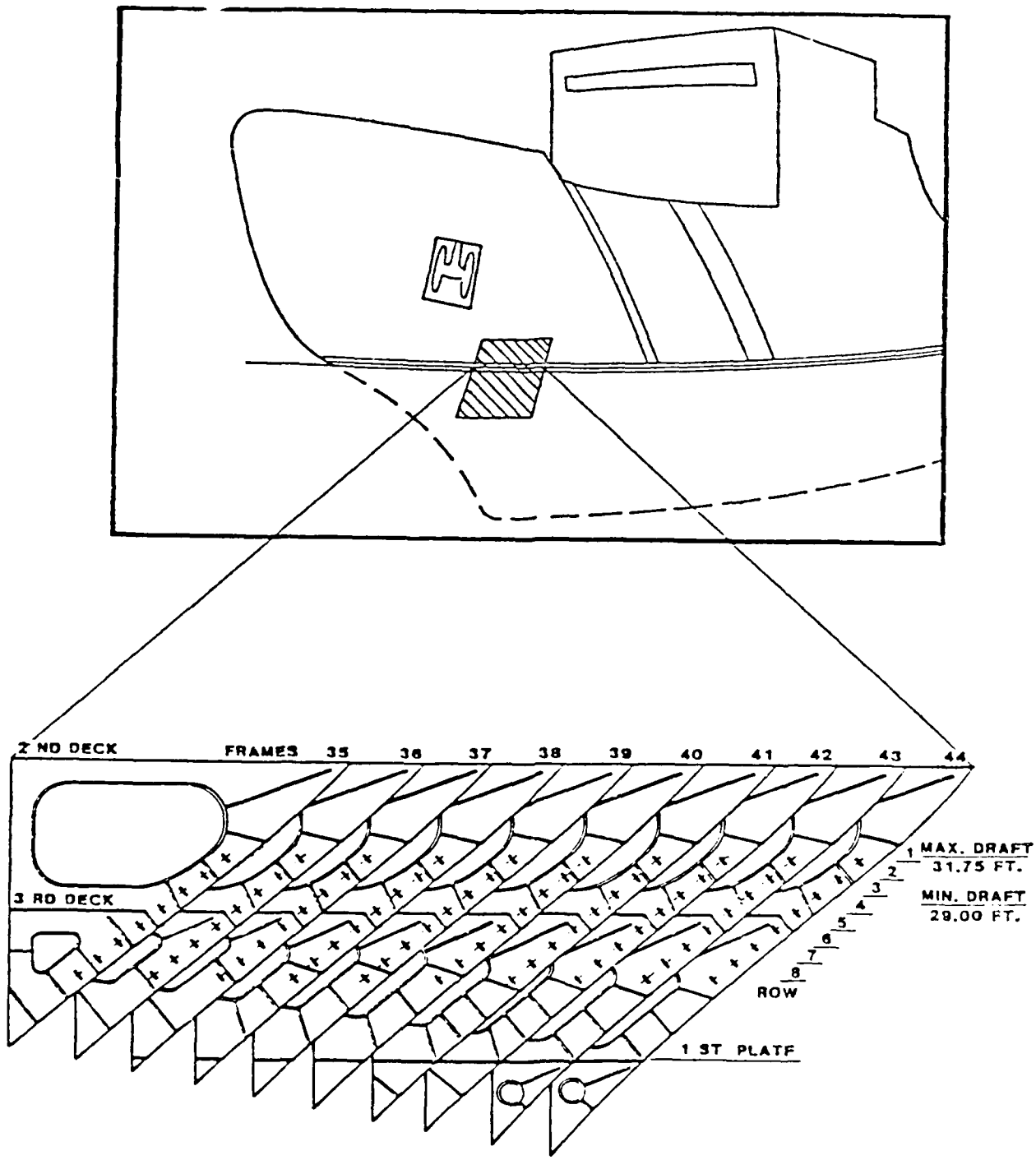


Figure 1

STRAIN GAGE LOCATIONS FOR INSTRUMENTED BOW PANEL ABOARD POLAR SEA

2.0 NARRATIVE OF DATA COLLECTION ACTIVITIES AND OBSERVED ICE CONDITIONS

Ice impact data were collected during the transit of POLAR SEA from Barter Island to Nome, Alaska. Operations were conducted in the Beaufort Sea from November 18 until November 30, 1984 and in the north Chukchi Sea on November 30 and December 1, 1984. Three hundred thirty-seven events, each of five second duration, were recorded during these dates. Of the 337 events, 32 are known multiyear events.

Personnel boarded POLAR SEA on November 11 about 100 n.m. north of Barter Island. The ship then proceeded to a position just offshore Barter Island which was reached on November 14. Data collection software revisions were made during this time and no data were collected.

Ice conditions from Barter Island to a position 60 n.m. offshore Prudhoe Bay were generally mild in the sense that POLAR SEA operated in a shore lead for most of the distance. Level ice thickness in the lead was under one foot (.3 m), but some thicknesses as high as 2 to 3 ft (.6 to .9 m) were experienced. The largest pressure ridge transited had a sail height of about 5 ft (1.5 m) although some were observed in the vicinity to be as high as 15 ft (4.6 m). Multiyear ice floes were also encountered during the transit. Ice impact data collection began on November 18 and continued through November 21. By this time about 100 ice impacts were recorded, mostly from first year ridges. On November 21 POLAR SEA became stuck in an active shear ridge which halted data collection for six days.

During the period of November 27 through November 29, about 300 events were recorded, many of which were impacts with multiyear ice. During this part of the transit, from Prudhoe Bay to Barrow, ice conditions were highly irregular. Avoidance of difficult ice features which might cause POLAR SEA to become stuck again was paramount. As a result, considerable ice maneuvering was performed which allowed POLAR SEA to transit much of this distance in thin level ice 2 ft (.6 m) or less in thickness. Pressure ridges were encountered throughout this part of the transit as well as multiyear ice. The maximum ridge sail height transited was reported as 8 ft (2.4 m), although the majority were under 3 ft (.9 m). Multiyear ridges were relatively few compared to the number of multiyear floes. Detection of multiyear floes could not be determined until the ship was on the verge of impact because most of the floes were small and many lacked pressure ridges making early detection difficult in the available lighting conditions. The last sunrise occurred a week before.

On November 30, a partial transfer of personnel was made at Barrow. Data collection continued for two more days and on December 2, the ice impact data collection instrumentation was shut down for removal at Nome and the final departure of project personnel.

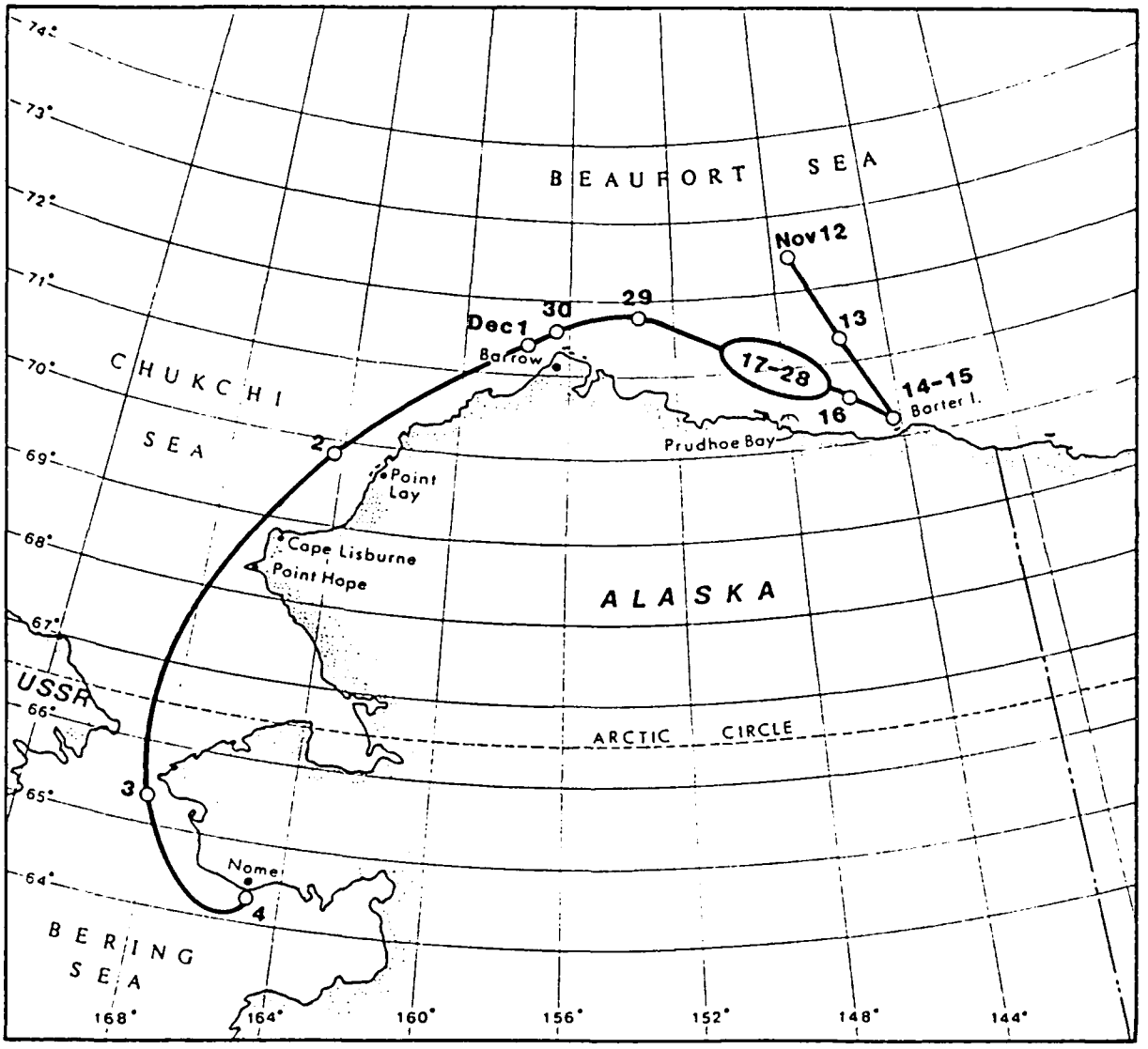


Figure 2

USCGC POLAR SEA POSITION AT 0800 HOURS
November 12 - December 4, 1984

3.0 TEST RESULTS

3.1 Overview of the Measured Loads

The 337 events that were recorded are of excellent quality. The impacts are extremely well centered on the panel and occurred over a wide range of speeds. To aid in understanding the loads measured on the panel, Table 1 gives the conversion from number of sub-panels to area in square feet and square meters for use with Tables 2 and 3. Tables 2 and 3 show the frequency of impacts versus highest average pressure for different contact areas for the entire data set and the known multiyear data set, respectively. Approximately 37 percent of the impacts have contact areas of at least 50 ft^2 (4.7 m^2). One exceptional event occurred which had a peak pressure of 1041 psi (7.2 MPa). This was very localized affecting three sub-panels at the time of peak pressure. As shown in Table 2, all the events above 400 psi (2.8 MPa) were very localized having contact areas at the time of peak pressure less than 9.8 ft^2 (0.9 m^2).

Tables 4 and 5 show the frequency of impacts as a function of panel location for peak pressure and peak force, respectively. These tables show that the impacts are well centered on the panel. Frame 40 Row 6 has an unusually high number of occurrences. No obvious explanation is apparent, however.

Figures 3 and 4 are scatter diagrams showing peak pressures and peak forces plotted versus ship speed, respectively. Impacts were recorded over a range of ship speeds from 0.5 kt to almost 6 kts (0.25 to 3.1 mps). An intermittent problem with the speed channel caused some loss of velocity data. Impact velocities were obtained for most of this data by detailed analysis of the velocity time-histories. Only in cases where the system was down for the entire 5 second event was there a loss of impact speed. These impacts are not included in the figures. The figures show that the impacts were distributed evenly over the range of ship speed indicating that there is no apparent relationship between peak pressure and ship speed. The extremes of panel force show a weak trend of increasing severity with increasing speed.

TABLE 1 CONVERSION FROM NUMBER OF SUB-PANELS TO AREA

NUMBER OF SUB-PANELS	AREA FT^2	AREA M^2
1	1.63	0.15
6	9.79	0.91
15	24.5	2.28
31	50.6	4.70
46	75.1	6.98
60	97.9	9.10

TABLE 2 FREQUENCY OF IMPACTS VERSUS HIGHEST AVERAGE PRESSURE FOR BEAUFORT SUMMER 1984 DATA

PRESSURE (psi)	NUMBER OF SUB-PANELS 1	6	15	31	46	60
0-50	0	42	102	103	3	0
50-100	4	83	128	20	1	0
100-150	20	104	29	1	0	0
150-200	21	65	3	0	0	0
200-250	34	21	1	0	0	0
250-300	50	4	0	0	0	0
300-350	62	3	0	0	0	0
350-400	40	1	0	0	0	0
400-450	35	0	0	0	0	0
450-500	18	0	0	0	0	0
500-550	20	0	0	0	0	0
550-600	12	0	0	0	0	0
600-650	3	0	0	0	0	0
650-700	4	0	0	0	0	0
700-750	5	0	0	0	0	0
750-800	5	0	0	0	0	0
800-850	3	0	0	0	0	0
1000-1050	1	0	0	0	0	0
TOTALS	337	323	263	124	4	0

TABLE 3 FREQUENCY OF IMPACTS VERSUS HIGHEST AVERAGE PRESSURE FOR KNOWN MULTIYEAR IMPACTS IN THE BEAUFORT SUMMER 1984 PROGRAM

PRESSURE (psi)	NUMBER OF SUB-PANELS 1	6	15	31	46	60
0-50	0	4	11	2	0	0
50-100	0	10	8	3	0	0
100-150	1	6	6	0	0	0
150-200	2	6	0	0	0	0
200-250	7	5	0	0	0	0
250-300	3	0	0	0	0	0
300-350	5	0	0	0	0	0
350-400	1	0	0	0	0	0
400-450	4	0	0	0	0	0
450-500	2	0	0	0	0	0
500-550	1	0	0	0	0	0
550-600	2	0	0	0	0	0
600-650	0	0	0	0	0	0
650-700	1	0	0	0	0	0
700-750	1	0	0	0	0	0
750-800	1	0	0	0	0	0
800-850	0	0	0	0	0	0
1000-1050	1	0	0	0	0	0
TOTALS	32	31	25	5	0	0

TABLE 4 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK PRESSURE

	FRAMES										
ROWS	44	43	42	41	40	39	38	37	36	35	TOTAL
3	2	1	8	4	3	4	2	9	3	0	36
4	4	10	4	6	1	0	7	10	5	4	51
5	2	13	6	6	7	6	13	11	9	3	76
6	2	5	3	1	75	0	3	2	2	0	93
7	0	0	2	2	1	5	3	18	14	4	49
8	1	5	4	3	1	6	2	2	8	0	32
TOTAL	11	34	27	22	88	21	30	52	41	11	337

TABLE 5 FREQUENCY OF IMPACTS VERSUS LOCATION AT TIME OF PEAK PRESSURE

	FRAMES										
ROWS	44	43	42	41	40	39	38	37	36	35	TOTAL
3	3	3	8	2	3	1	1	4	2	0	27
4	3	13	1	7	4	0	6	5	3	3	45
5	5	11	5	3	5	1	6	14	13	3	66
6	8	3	1	0	105	0	2	0	1	0	120
7	3	0	3	1	0	1	0	10	15	8	41
8	2	7	1	6	0	11	4	3	3	1	38
TOTAL	24	37	19	19	117	14	19	36	37	15	337

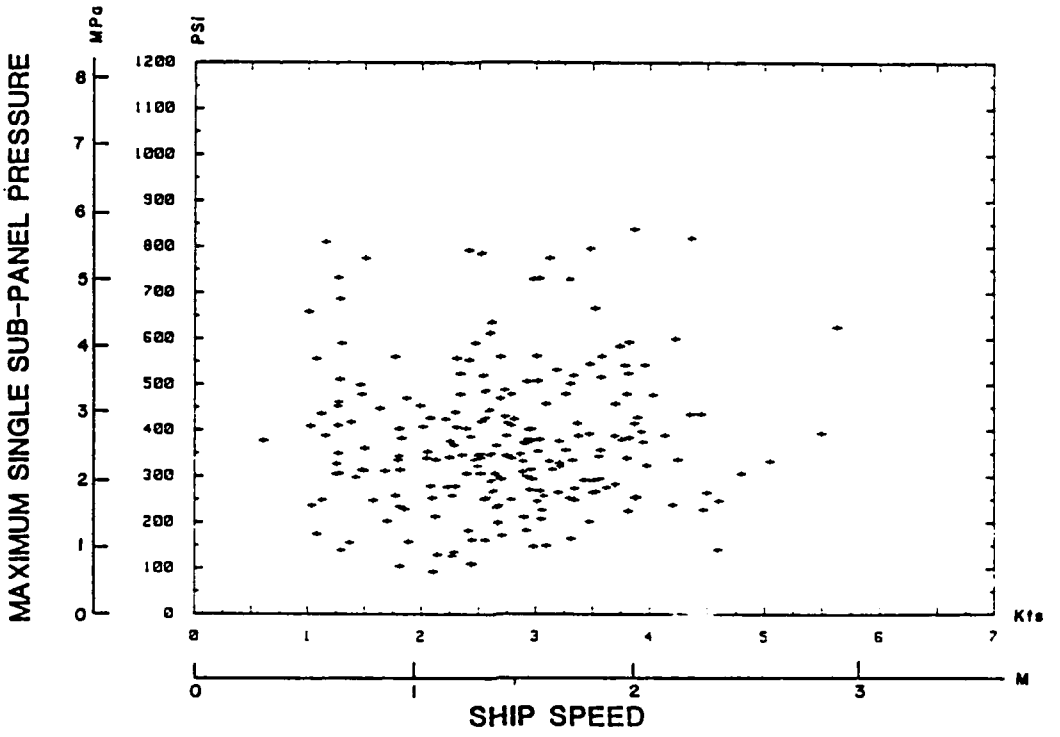


Figure 3

HIGHEST AVERAGE PRESSURE ON ONE SUB-PANEL
vs. SHIP SPEED

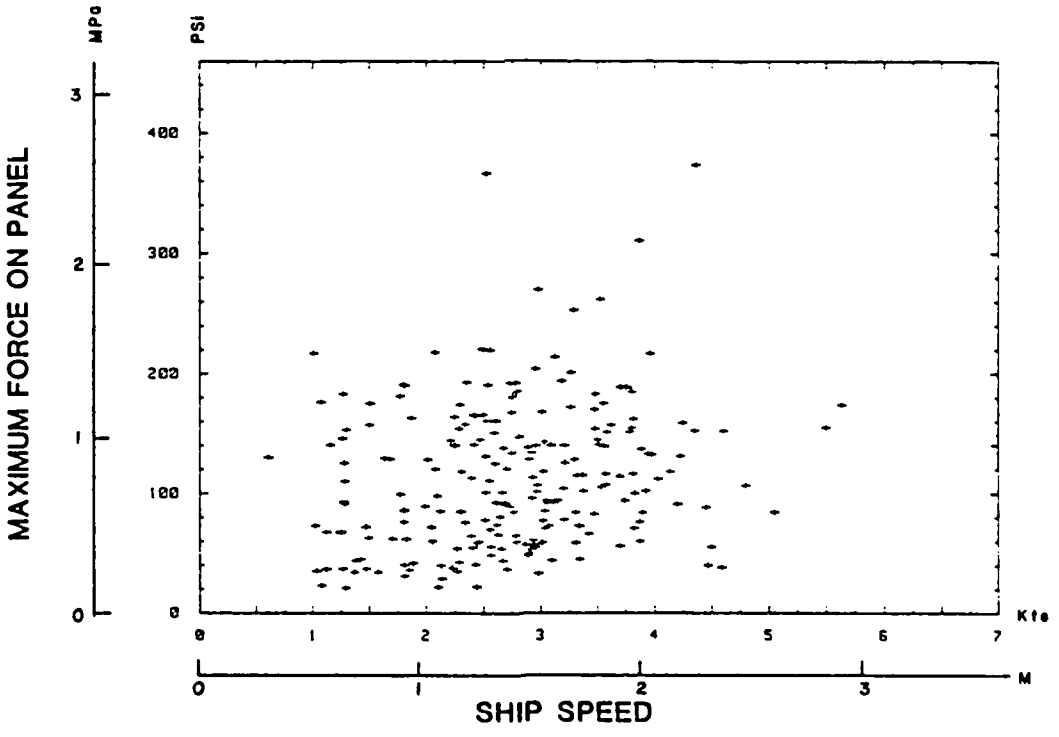


Figure 4

TOTAL PANEL PEAK FORCE vs. SHIP SPEED

3.2 Pressure Variation with Contact Area and Comparison with Previous Data

The data analysis plots the highest average pressure during each event verus impact area, impact length along a frame and impact length along a waterline. These are the formats that would be most useful to a designer. All of the events are then analyzed to determine the extremes of these data for the deployment, i.e. the extreme envelope of pressure for all events. Figure 5 shows a comparison of the highest average pressure versus impact area for all data from Beaufort Summer 1982 and Beaufort Summer 1984 deployments. In 1984, the pressures recorded for small impact areas are lower than in 1982 by a significant amount (more than 570 psi or 3.9 MPa). The 1982 envelope curve has a more typical shape, approaching a line of constant force at large contact areas. The 1984 curve is relatively linear over the entire range of impact areas. Simiarly, the maximum recorded force in 1982 was significantly higher, 495 LT versus 374 LT in 1984.

The ice conditions in 1982 and 1984 had significant differences which presumably contributed to the differences in measured pressures. Multiyear ice was much more severe in 1982 and, since the deployment was earlier in the season, the ship operated in open water or light refreeze between the floes. The ship therefore had room to maneuver and accelerate in open water before impacting the floes. This was not the case in 1984. The multiyear floes were smaller and fully embedded in first year ice about two feet thick.

Curves from the Beaufort Summer 1984 deployment are also presented for the highest average presure versus length along a frame and a waterline in Figures 6 and 7, respectively. Both show the typical exponential decay with distance (these approach straight lines of constant force when translated to the log-log pressure-area curve.)

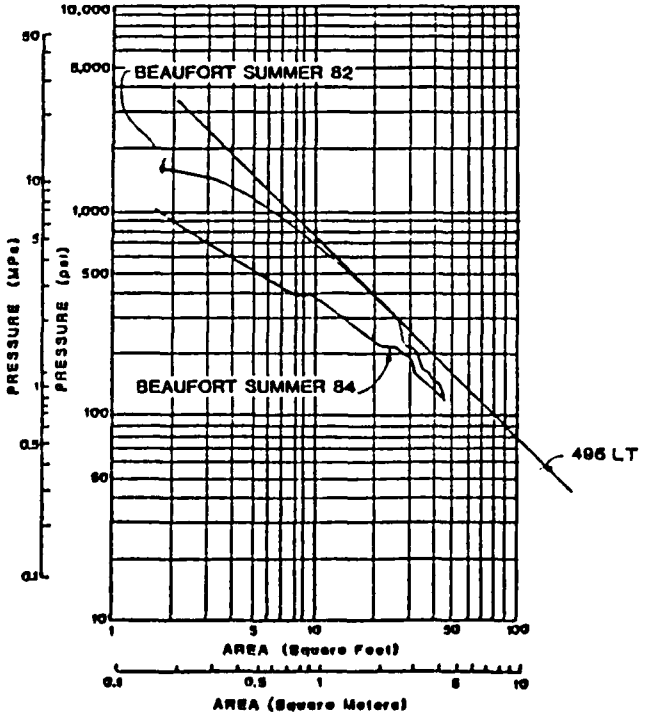


Figure 5

HIGHEST AVERAGE PRESSURE FOR ALL DATA FROM BEAUFORT SUMMER 82 AND BEAUFORT SUMMER 84 vs. IMPACT AREA

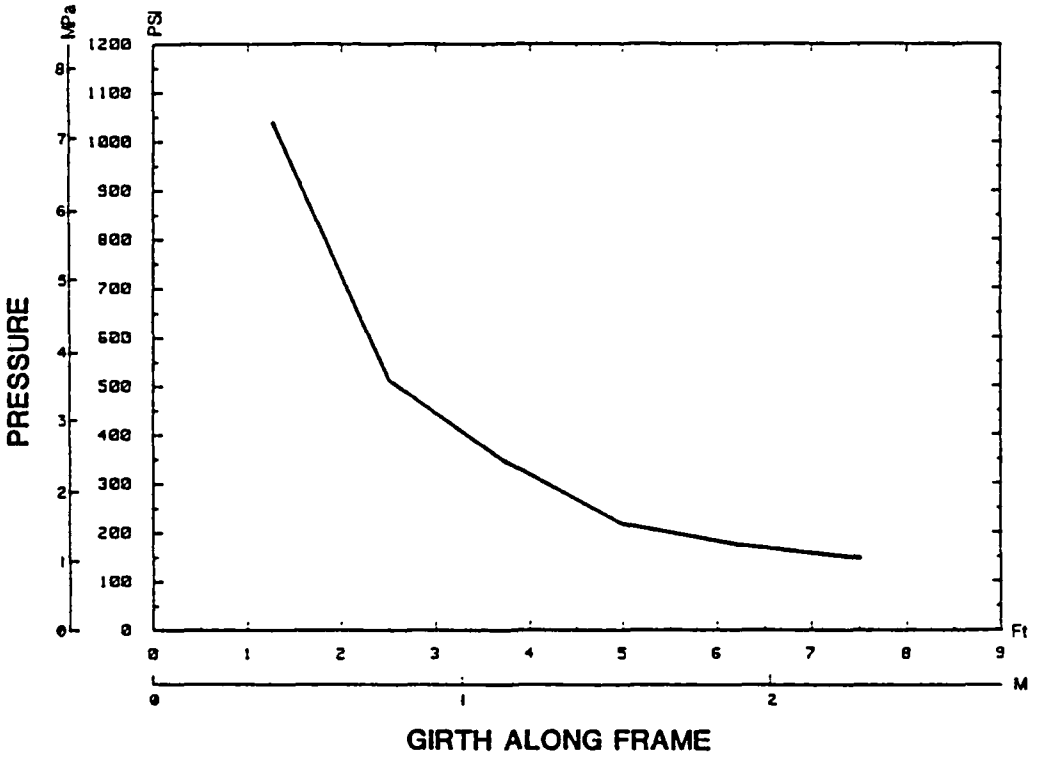


Figure 6
HIGHEST AVERAGE PRESSURE FOR ALL BEAUFORT SUMMER 84
DATA vs. IMPACT LENGTH ALONG A FRAME
(VERTICAL SLICE THROUGH THE PANEL)

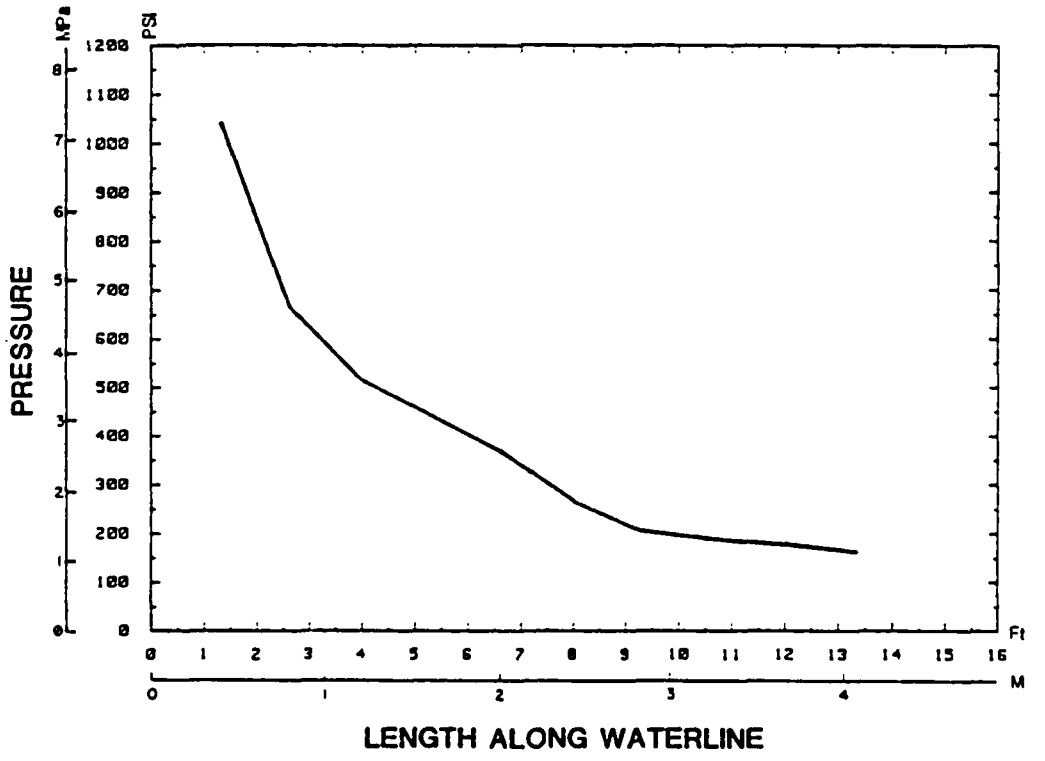


Figure 7
HIGHEST AVERAGE PRESSURE FOR ALL BEAUFORT SUMMER 84
DATA vs. IMPACT LENGTH ALONG A WATERLINE
(HORIZONTAL SLICE THROUGH THE PANEL)

3.3 Pressure and Contact Area Variation with Time

To better understand the ice impact process, it is of interest to examine the variation of peak and average pressure and contact area with time. These are the important variables used in many mathematical models of ice-structure interaction.

Three events have been analyzed and are presented in Appendix E. The one of those three events presented in Figures 8 and 9 includes the highest single sub-panel pressure recorded on the deployment (1041 psi or 7.2 MPa). For this event, contact area increases very rapidly and then levels off while there is a steady rise in average and peak pressure in the early part of the impact. Maxima in average pressure occur at local minima in the contact area. The extreme of peak pressure occurs as contact area is rapidly decreasing. Peak pressure has less fluctuation with changes in contact area where average pressure appears directly correlated. Similar trends were seen in the event shown in Figures 46 and 47 of Reference 1 where sudden drops in the contact area caused corresponding sudden increases in the average pressure near the time of the maximum single sub-panel pressure. The sudden decreases in contact area could be caused by flaking of ice pieces near the edge of the impact zone typical of brittle failure of ice. The early stages of the event of Figures 8 and 9 also shows a simultaneous increase in average and peak pressure and contact area indicating confinement effects. This phenomenon is evident in other events shown in Reference 1 as well.

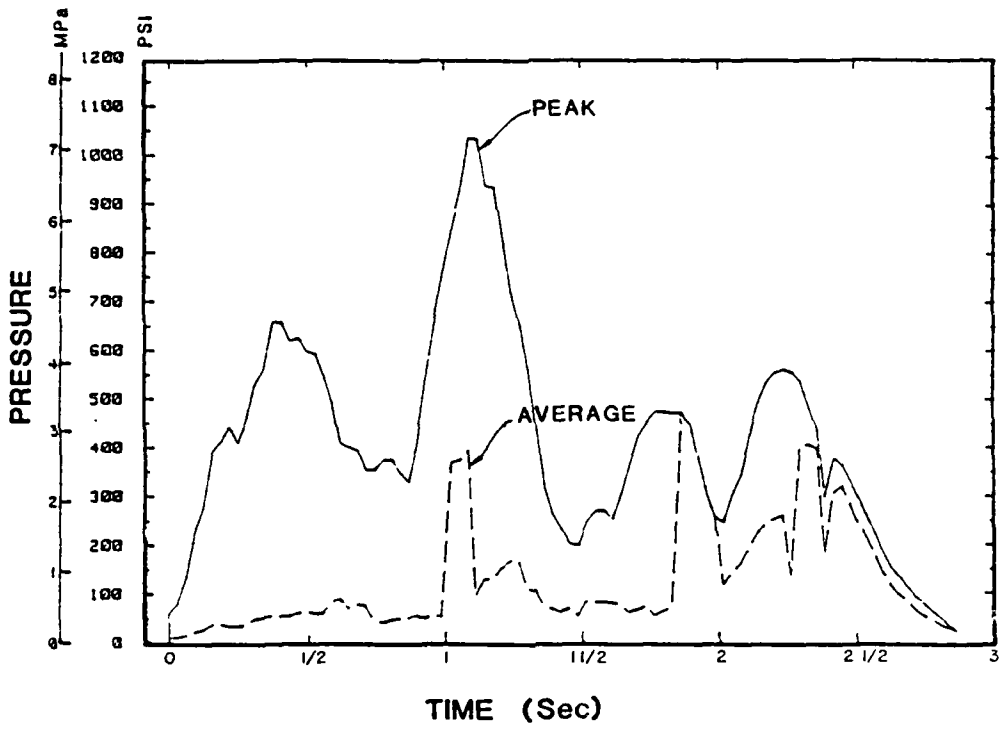


Figure 8
EVENT ON 28 NOV 1984 AT 19:19:4
SHOWING PEAK AND AVERAGE PRESSURE VARIATION WITH TIME

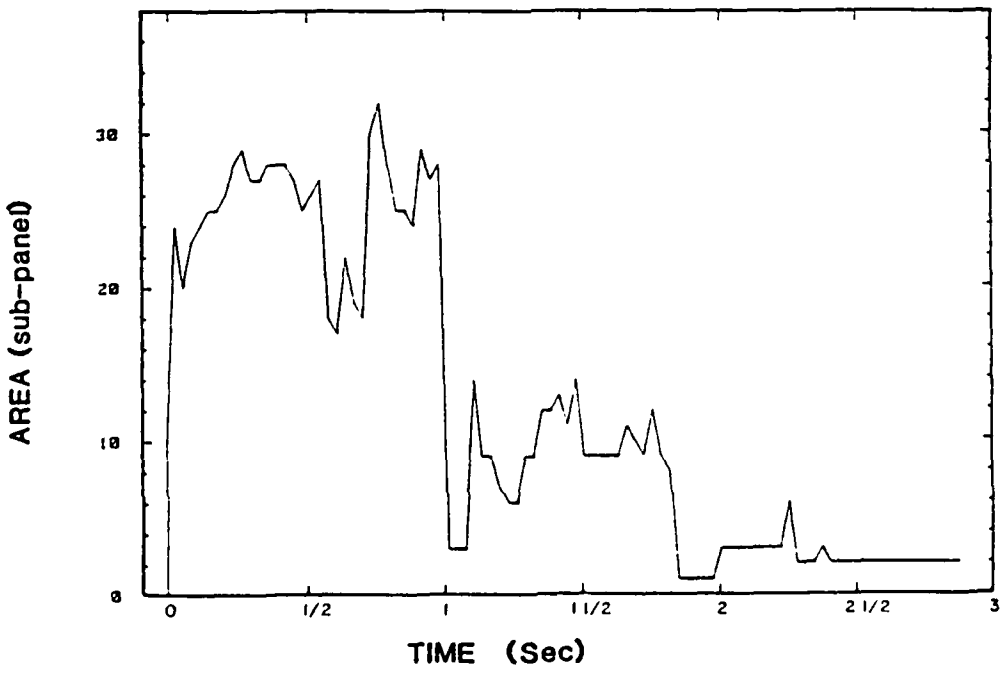


Figure 9
EVENT ON 28 NOV 1984 AT 19:19:4
SHOWING CONTACT AREA VARIATION WITH TIME

3.4 Statistical Analysis of the Extreme Loads

The 337 recorded impacts were rank ordered by highest single sub-panel pressure, by highest average pressure over four sub-panels and by highest total panel force. The probability of occurrence was computed for each ranking as the reciprocal of one plus the order number. One minus the probability of occurrence is the probability of non-occurrence or the probability that, given an impact, the measured value will be less than the given value.

The three data sets are plotted on extreme value probability paper in Figures 10, 11, and 12. All three plots show a linear relationship of forces or pressures to probability indicating a Gumbel type distribution. The three types of asymptotic extreme value distributions have been discussed in previous reports [1,4].

A subset of 32 of the 337 recorded events were known multiyear events and these were analyzed seperately. Figures 13, 14 and 15 show the extreme value plots for highest average pressure over one sub-panel, four sub-panels and total force on the panel, respectively. While it is much more difficult to see a trend in the data due to a small data set, Figures 14 and 15 show a general linear pattern indicating a Gumbel type distribution. This type of extreme value distribution plots linearly on log-extreme value paper. The single sub-panel pressures shown in Figure 13, however, have a definite upward curvature indicating a Frechet or Type II distribution.

The Frechet distribution for single sub-panel multiyear events agrees with the data from 1982 taken in the summer Beaufort Sea. The data from 1982 were much more severe, however, and the distribution of all events from that data set was a Frechet distribution. A Gumbel distribution is appropriate for all data from 1984 as shown in Figure 10. Upward curvature appears to increase with increasing severity of multiyear ice. The comparison of data sets will be discussed in more detail in Volume II.

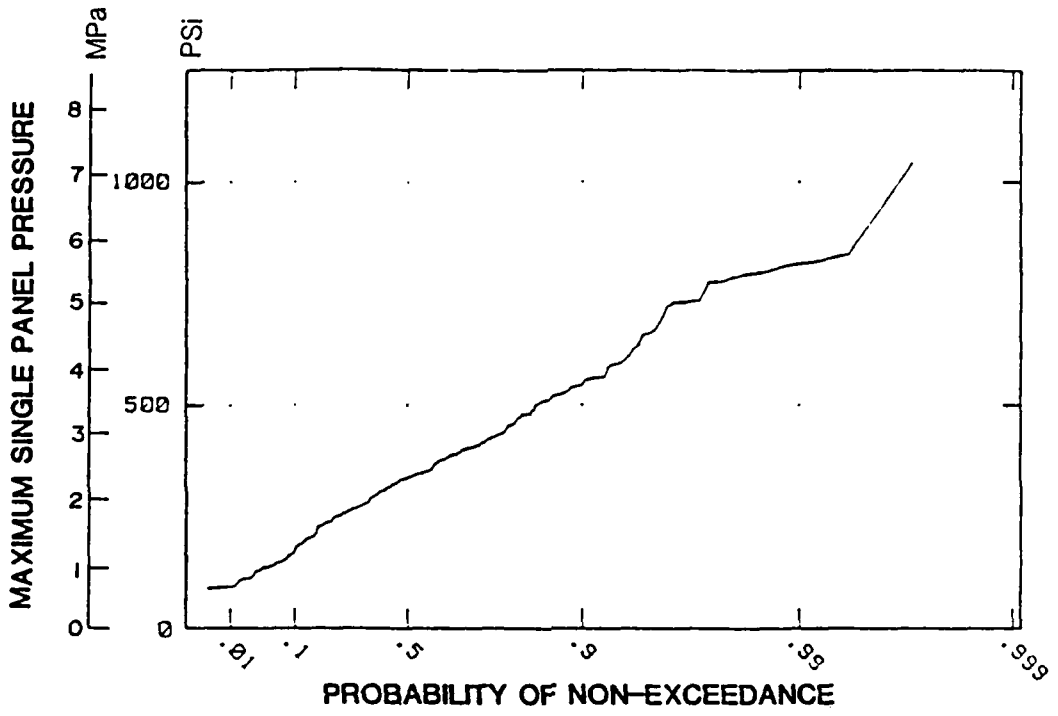


Figure 10

EXTREME VALUE DISTRIBUTION OF HIGHEST AVERAGE PRESSURE ON A SINGLE SUB-PANEL FROM THE BEAUFORT SUMMER 84 DATA

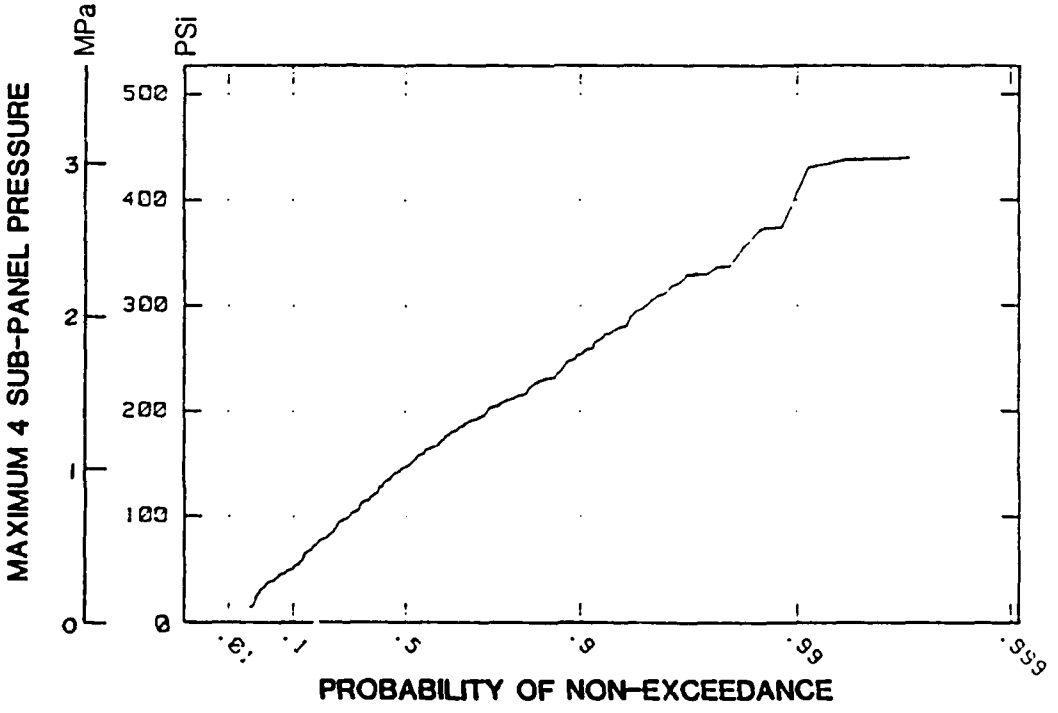


Figure 11

EXTREME VALUE DISTRIBUTION OF HIGHEST AVERAGE PRESSURE ON FOUR SUB-PANELS FROM THE BEAUFORT SUMMER 84 DATA

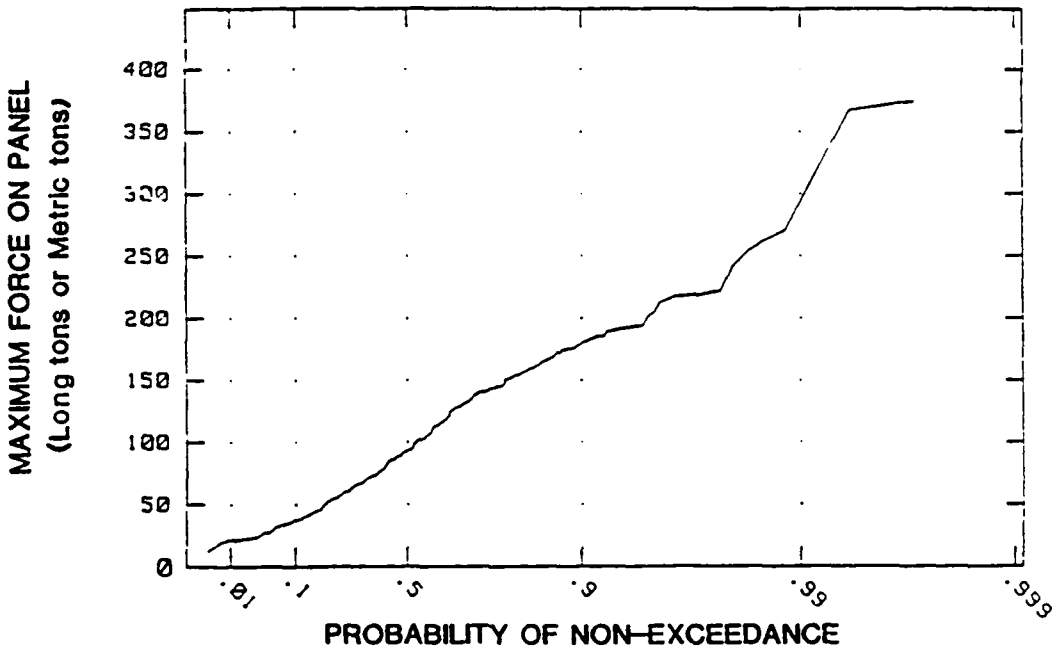


Figure 12
EXTREME VALUE DISTRIBUTION OF HIGHEST FORCE
ON THE ENTIRE PANEL FROM THE BEAUFORT SUMMER 84 DATA

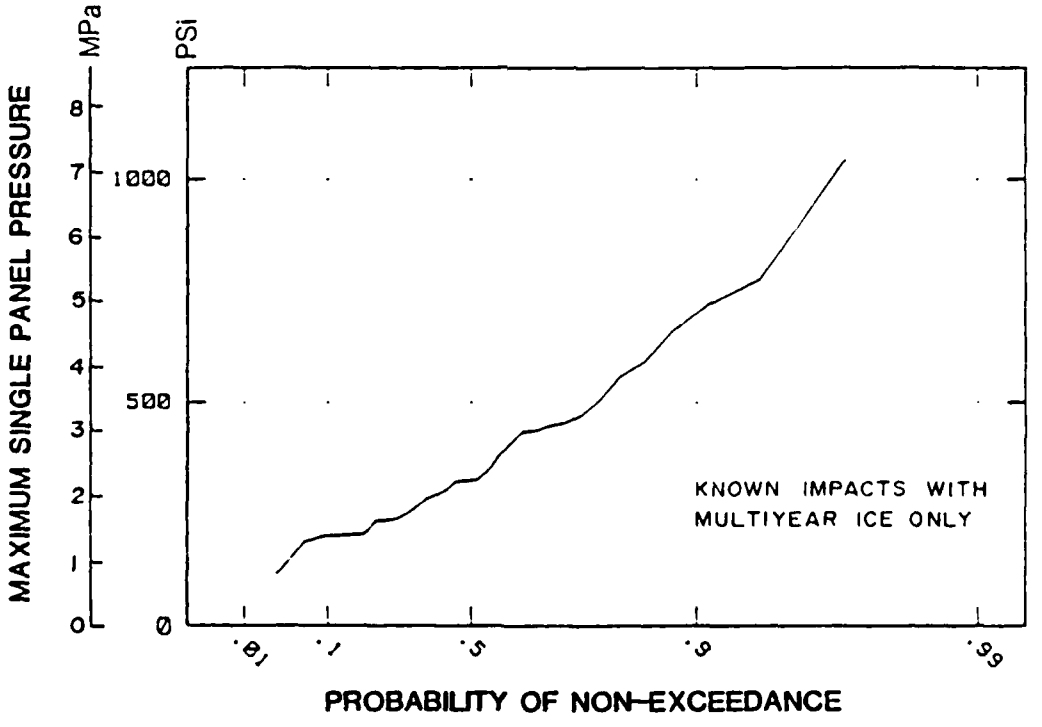


Figure 13
EXTREME VALUE DISTRIBUTION OF HIGHEST AVERAGE PRESSURE
ON A SINGLE SUB-PANEL FROM THE BEAUFORT SUMMER 84 MULTIYEAR DATA

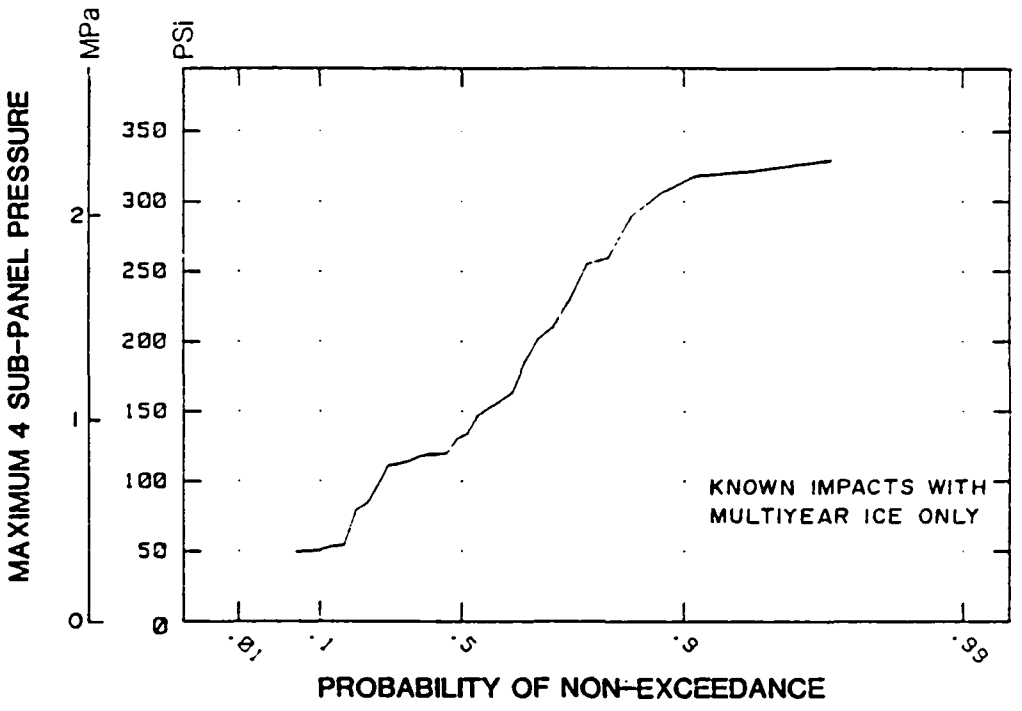


Figure 14

EXTREME VALUE DISTRIBUTION OF HIGHEST AVERAGE PRESSURE ON FOUR SUB-PANELS FROM THE BEAUFORT SUMMER 84 MULTİYEAR DATA

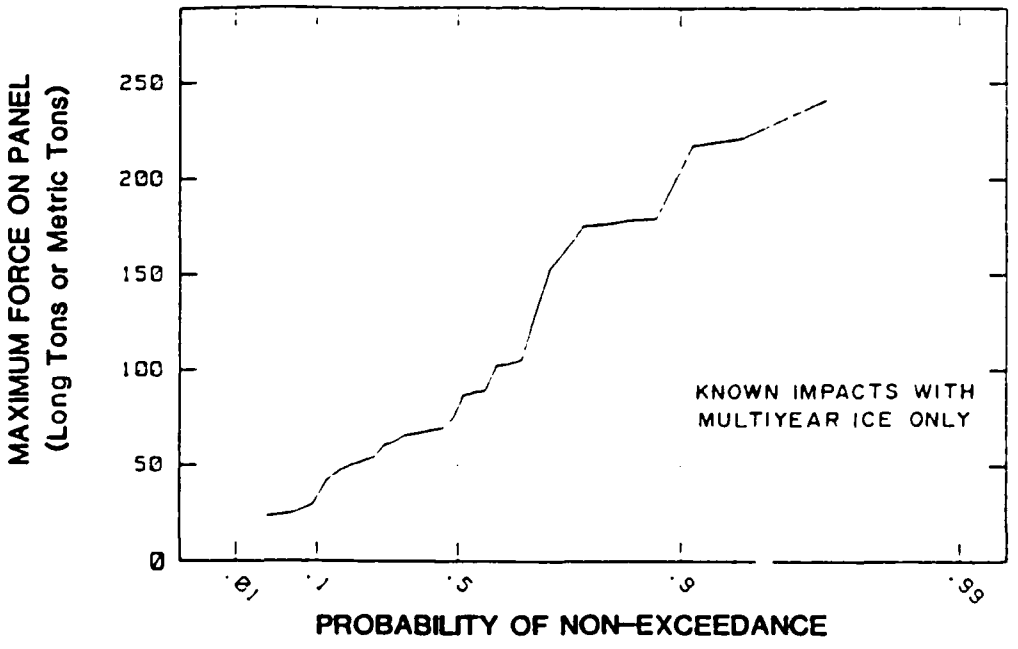


Figure 15

EXTREME VALUE DISTRIBUTION OF HIGHEST FORCE ON THE ENTIRE PANEL FROM THE BEAUFORT SUMMER 84 MULTIYEAR DATA

4.0 VERIFICATION OF CONSISTENT PANEL RESPONSE

As part of the 1984 Beaufort Sea tests, the panel was physically loaded with known forces to verify that the response of the panel had not changed with time. When the strain gages were originally installed in the POLAR SEA, padeyes were installed on the inside of the hull plating between the frames such that the strain gages could be loaded with a known load. The padeyes were placed between frames 37 and 38, 39 and 40, 41 and 42, and between 43 and 44 at three vertical locations in each frame bay. Each padeye was loaded individually to approximately 40 LT (40 MT) and the strains were read at all gages for each load. The original 1982 test results were compared to a finite element model of the area that was given the same loading conditions. The objective of the 1982 test was to validate the finite element model such that it could be used to generate the data reduction matrix to reduce the strains from an ice impact to uniform pressures on the hull.

Tables 6, 7 and 8 show the results of repeating the measured loading at 12 places on the panel in 1984. The tables compare the results to the previous test and the finite element calculations. The results of both measurements are extremely similar. Overall error relative to the finite element model results actually improved slightly from the 1982 test. The conclusion is that the panel has not changed its response significantly over the span of time it has been used for testing.

The 1984 tests were performed about three weeks after the measurements were taken in the Beaufort Sea. Blanks in the tables indicate gages that failed during the testing period or on the return trip to Seattle and were not replaced.

TABLE 6 COMPARISON OF MEASURED AND COMPUTED STRAINS AT THE UPPER PADEYE

ROW	FEM	FRAMES 37	38	39	40	41	42	43	44	ERROR με MAX	MIN	AVG	RMS
1	10	28	28	31	26	25	25	31	23	21	13	17.1	6.1
		28	28	29	25	24	24	25	26	25	14	17.4	6.3
2	63	34	51	58	50	59	56	58	57	- 4	-29	-10.1	4.5
		37	53	60	55	63	60	63	58	0	-26	- 6.9	3.7
3	31	32	33	29	28	39	43	38	40	12	- 3	4.3	2.6
		35	35	30	30	38	58	39	43	27	-1	7.5	4.0
4	15	12	14	17	13	17	12	20	17	5	- 3	0.3	1.0
		13	16	-	14	13	11	23	19	8	-4	0.6	1.5
5	4	2	- 1	6	0	- 2	- 2	- 2	- 4	2	- 8	- 4.4	1.9
		2	0	-1	0	- 2	- 1	- 2	- 3	- 2	- 7	- 4.9	1.8
6	0	4	6	3	3	6	4	4	4	6	3	4.3	1.6
		4	5	4	4	-	6	5	-	6	4	4.7	1.9
	AVG	- 1.8	1.3	3.5	- 0.5	3.5	2.5	4.3	2.2			1.9	
		- 0.7	2.3	2.8	0.8	2.6	5.8	6.7	4.0			3.1	
	RMS	5.8	3.9	3.7	3.6	3.3	3.7	4.1	3.3				1.4
		5.3	3.7	4.1	3.0	3.4	5.3	4.8	4.4				1.6

TABLE 7 COMPARISON OF MEASURED AND COMPUTED STRAINS AT THE MIDDLE PADEYE

ROW	FEM	FRAMES 37	38	39	40	41	42	43	44	ERROR με MAX	MIN	AVG	RMS
1	- 5	1	1	1	2	- 3	- 3	- 2	- 4	7	1	4.1	1.7
		2	1	1	1	- 2	- 3	- 1	- 4	7	1	4.4	1.7
2	- 4	- 1	- 7	- 9	- 8	- 9	- 7	- 4	- 7	3	- 5	-2.5	1.3
		- 2	- 7	- 8	-10	-10	-10	- 7	- 7	2	- 6	-3.6	1.6
3	7	16	12	16	15	12	16	26	21	19	5	9.8	3.8
		18	13	16	15	15	20	26	22	19	6	11.1	4.2
4	81	77	75	86	85	85	60	92	82	11	-21	-0.8	3.2
		84	84	-	87	82	64	93	86	12	-17	1.9	3.2
5	40	33	34	27	33	31	34	29	24	- 6	-16	-9.4	3.5
		42	37	23	39	32	13	29	27	2	-27	-9.8	4.6
6	5	11	11	8	7	9	9	9	10	6	2	4.25	1.6
		11	12	12	4	-	10	10	-	7	- 1	4.8	2.3
	AVG	2.2	0.3	0.8	1.7	0.2	- 2.5	4.3	0.3			0.9	
		5.2	2.7	0.2	2.0	-0.4	- 5.0	4.3	1.0			1.5	
	RMS	2.5	2.2	3.1	2.4	2.2	4.0	4.2	3.7				1.1
		2.5	2.0	4.3	2.2	2.6	5.9	4.3	4.1				1.3

TABLE 8 COMPARISON OF MEASURED AND COMPUTED STRAINS AT THE LOWER PADEYE

ROW	REM	FRAMES 37	38	39	40	41	42	43	44	ERROR με MAX	MIN	AVG	RMS
3	- 3	- 1	- 1	- 2	- 3	0	- 1	- 1	0	3	0	1.9	0.7
		- 1	- 1	- 1	- 2	- 6	- 2	- 2	- 2	2	- 3	0.9	0.6
4	- 6	- 7	- 7	- 8	- 8	- 5	- 4	- 6	- 7	2	- 2	- 0.5	0.5
		- 8	- 8	-	- 8	- 8	- 4	- 7	- 8	2	- 2	- 1.3	0.7
5	- 8	- 5	- 4	- 4	- 8	- 4	- 2	- 2	- 3	6	0	4.0	1.6
		- 9	- 7	- 9	-10	- 7	- 2	- 5	- 7	6	- 2	1.0	0.9
6	36	50	25	48	39	42	40	48	43	14	-11	5.9	3.3
		55	26	50	-	-	38	47	-	19	-10	7.2	5.6
7	102	77	75	77	76	84	73	70	78	-18	-32	-25.8	9.2
		89	83	87	84	85	73	-	79	-13	-29	-19.1	7.5
8	27	- 8	50	10	6	27	17	12	15	23	-35	-10.9	6.8
		-12	55	11	7	26	17	11	15	28	-39	-10.8	7.4
	AVG	- 7.0	- 1.7	- 4.5	- 7.6	- 0.7	- 4.2	- 4.5	- 3.7			- 4.2	
		- 5.7	0.0	3.2	- 8.2	- 4.4	- 4.7	- 0.4	- 7.0			- 3.7	
	RMS	7.5	6.2	5.5	5.6	3.3	5.3	6.3	4.7				2.0
		7.6	5.9	5.2	5.4	3.5	5.2	3.9	5.2				2.0

AVG OF ALL DATA -1.4 με
RMS OF ALL DATA 0.9 με

5.0 SUMMARY AND CONCLUSIONS

A total of 337 events were collected in the Beaufort Sea in summer multiyear ice conditions. Ship impact speed ranged from 0.5 to almost 6 kts. Ice conditions were generally less severe resulting in lower loads than in 1982. Extremes of the data showed a single sub-panel pressure as high as 1041 psi (7.2 MPa) and a maximum total panel force of 374 LT (380 MT). This pressure and force are about 65 and 75 percent, respectively, of those recorded on the previous deployment to the Beaufort Sea in 1982.

Conclusions from the study are as follows:

1. Speed effects were not apparent in the single sub-panel pressure data and only weakly evident in the total force data.

2. Total force and pressue data fit a Gumbel probability distribution for the events collected (337 events). Known multiyear data also fit a Gumbel distribution except for the single sub-panel pressure which fit a Frechet distribution, though there is a very small number of events.

3. Loading the panel with known forces, as was performed in 1982 for validation of the finite element model, showed no significant differences in the measured response.

No specific recommendations result from these measurements and their analysis. The entire measurement program, encompassing four ship deployments, is discussed in Volume II where recommendations are made for ice load design criteria.

6.0 REFERENCES

1. "Ice Loads and Ship Response to Ice", for Ship Structure Committee, U.S. Maritime Administration, and Transport Canada, SR-1291, December 1984.

2. "Local Ice Pressures Measured in Thick Level Ice in Antarctica", for Maritime Administration and U.S. Coast Guard, ARCTEC, Incorporated Report No. 929C, September 1986.

3. Daley, C., Brown, R., St. John, J., Meyers, J., "Polar Class Antarctic 1984 Ice Impact Tests", Transport Canada TP 7184E, by Arctec Canada Limited, March 1985.

4. Daley, C.G., St. John, J.W., Seibold, F., and Bayly, I., "Analysis of Extreme Ice Loads Measured on USCGC POLAR SEA", paper presented to The Society of Naval Architects and Marine Engineers, November 1984.

APPENDIX A

SUMMARY OF MEASURED DATA RANKED BY SINGLE SUB-PANEL PRESSURE

KEY:

- PM1 - Maximum single sub-panel pressure (psi)
- PA1 - Average pressure over the contact area at the time of peak pressure (psi)
- A1 - Contact area at the time of peak pressure (sub-panels)
- F1 - Total panel force at the time of peak pressure (LT)
- PM2 - Maximum single sub-panel force (psi)
- PA2 - Average pressure over the contact area at the time of peak force (psi)
- A2 - Contact area at the time of peak force (sub-panels)
- F2 - Peak total panel force (LT)
- VEL - Ship velocity at impact

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
18 NOV 1984	15:8:27	87	11	23	27	87	11	23	27	0.0
18 NOV 1984	15:15:28	90	31	6	20	36	12	17	21	0.0
18 NOV 1984	15:0:9	91	15	10	16	24	9	34	32	0.0
27 NOV 1984	15:20:46	93	15	14	22	93	15	14	22	0.0
1 DEC 1984	13:55:4	104	104	1	11	41	7	42	31	1.9
1 DEC 1984	13:53:32	109	13	16	22	109	13	16	22	2.3
1 DEC 1984	13:20:10	110	64	2	13	60	15	26	41	7.3
1 DEC 1984	13:49:38	111	111	1	12	55	7	16	12	.7
1 DEC 1984	13:50:20	117	20	12	25	97	11	25	29	.1
18 NOV 1984	13:7:39	126	31	5	16	81	20	13	27	0.0
1 DEC 1984	13:54:48	127	20	14	29	105	13	26	35	.1
27 NOV 1984	17:14:23	130	130	1	14	37	9	31	29	0.0
18 NOV 1984	13:53:10	134	12	21	26	128	15	17	27	0.0
18 NOV 1984	10:32:31	135	35	5	18	87	21	11	24	0.0
1 DEC 1984	13:39:8	135	34	9	32	61	12	34	43	-.2
18 NOV 1984	10:39:58	136	24	13	33	62	14	25	37	0.0
29 NOV 1984	19:59:7	139	26	7	19	25	6	34	21	2.2
1 DEC 1984	15:13:59	139	53	3	17	94	25	8	21	1.4
1 DEC 1984	13:8:51	140	33	7	24	63	9	40	38	4.5
18 NOV 1984	10:41:22	145	145	1	15	117	61	9	58	0.0
1 DEC 1984	13:52:11	145	78	2	16	142	14	13	19	0.0
1 DEC 1984	14:24:14	146	21	9	20	115	79	4	33	2.8
18 NOV 1984	10:35:25	147	44	14	65	137	45	14	66	0.0
1 DEC 1984	13:36:4	149	15	13	20	61	13	32	44	3.1
18 NOV 1984	13:1:33	150	14	15	22	150	14	15	22	0.0
18 NOV 1984	10:39:10	152	52	5	27	147	36	27	102	0.0
1 DEC 1984	13:36:51	156	43	4	18	79	16	20	34	3.0
1 DEC 1984	13:36:18	158	70	3	22	64	10	40	42	2.7
28 NOV 1984	5:58:52	162	39	9	37	114	14	40	59	2.5
1 DEC 1984	15:2:55	162	48	5	25	83	15	31	49	2.6
18 NOV 1984	15:8:11	165	14	28	41	165	14	28	41	0.0
27 NOV 1984	18:32:31	165	36	7	26	102	20	28	59	0.0
28 NOV 1984	3:42:40	170	36	5	19	39	10	35	37	0.0
1 DEC 1984	13:37:17	175	22	10	23	175	22	10	23	7.0
27 NOV 1984	20:10:16	182	95	2	20	152	18	29	55	0.0
1 DEC 1984	13:40:3	182	76	3	24	111	16	32	54	6.1
28 NOV 1984	4:29:31	186	78	5	41	155	32	18	60	0.0
18 NOV 1984	14:52:0	187	43	7	32	71	9	36	34	0.0
19 NOV 1984	12:26:32	187	22	28	65	187	22	28	65	0.0
18 NOV 1984	14:55:46	189	18	14	26	70	10	36	38	0.0
18 NOV 1984	10:38:37	190	46	7	34	46	12	31	39	0.0
18 NOV 1984	13:58:34	195	84	3	26	162	38	11	32	0.0
27 NOV 1984	18:49:58	195	44	6	28	136	38	8	32	0.0
1 DEC 1984	15:12:15	198	68	6	43	140	30	14	44	1.8
1 DEC 1984	13:50:30	199	199	1	21	184	24	9	23	.1
27 NOV 1984	20:1:45	200	27	16	45	87	25	18	47	0.0
28 NOV 1984	4:2:17	201	19	40	80	184	22	36	83	0.0
27 NOV 1984	20:10:37	202	202	1	21	173	17	14	25	0.0
18 NOV 1984	14:0:11	203	51	14	75	193	45	16	76	0.0
28 NOV 1984	4:29:0	203	203	1	21	166	33	19	62	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
29 NOV 1984	19:46:50	203	22	38	88	203	22	38	88	.1
29 NOV 1984	18:44:0	206	22	37	85	142	64	14	94	1.3
1 DEC 1984	14:14:22	210	74	3	23	70	13	37	50	.9
28 NOV 1984	3:7:12	212	25	29	76	177	27	30	85	0.0
18 NOV 1984	13:46:38	224	28	14	41	106	13	42	57	0.0
29 NOV 1984	18:32:54	224	28	38	112	224	29	38	116	7.0
18 NOV 1984	10:34:7	226	64	12	81	214	75	11	87	0.0
28 NOV 1984	5:40:53	226	36	19	72	184	35	25	92	0.0
29 NOV 1984	20:1:40	227	67	4	28	69	13	29	40	2.4
1 DEC 1984	15:13:51	228	38	9	36	228	38	9	36	1.9
18 NOV 1984	14:53:23	229	44	10	46	229	44	10	46	0.0
29 NOV 1984	6:0:16	231	46	19	92	231	46	19	92	2.1
18 NOV 1984	13:49:12	233	62	6	39	179	42	20	88	0.0
18 NOV 1984	13:17:50	234	24	25	63	179	41	16	69	0.0
28 NOV 1984	0:34:20	234	21	18	40	234	21	18	40	0.0
27 NOV 1984	21:4:59	235	64	4	27	235	64	4	27	0.0
28 NOV 1984	5:59:58	235	38	29	116	184	44	30	138	2.6
18 NOV 1984	13:11:7	236	35	11	40	77	12	41	52	0.0
29 NOV 1984	19:54:9	236	26	13	35	236	26	13	35	1.0
28 NOV 1984	16:15:11	237	36	24	91	237	36	24	91	4.6
27 NOV 1984	22:17:1	238	192	2	40	201	40	16	67	0.0
18 NOV 1984	13:7:26	242	152	3	48	105	15	33	52	0.0
28 NOV 1984	3:59:43	245	17	33	59	245	17	33	59	0.0
29 NOV 1984	19:49:2	246	31	21	68	167	33	44	152	1.4
27 NOV 1984	21:39:0	247	41	8	34	247	41	8	34	0.0
28 NOV 1984	9:14:10	248	140	2	29	109	20	31	65	0.0
29 NOV 1984	19:8:1	248	43	10	45	248	43	10	45	3.4
18 NOV 1984	13:49:27	249	20	17	36	177	64	8	54	0.0
1 DEC 1984	15:14:9	249	52	6	33	237	17	21	37	1.1
18 NOV 1984	10:39:50	250	68	16	114	238	81	15	127	0.0
29 NOV 1984	3:40:29	250	250	1	26	156	48	22	111	0.0
29 NOV 1984	19:7:24	252	35	33	121	236	36	34	128	.7
29 NOV 1984	19:32:6	253	40	12	50	63	15	38	60	3.2
1 DEC 1984	15:13:45	253	35	24	88	182	24	39	98	2.2
18 NOV 1984	14:49:36	254	60	5	31	214	78	4	33	0.0
29 NOV 1984	19:11:45	254	31	42	137	254	31	42	137	.1
1 DEC 1984	14:14:41	254	31	12	39	197	14	38	56	2.0
28 NOV 1984	3:20:38	257	29	20	61	253	33	21	73	0.0
29 NOV 1984	7:49:21	257	27	35	99	257	27	35	99	1.8
27 NOV 1984	20:19:31	258	258	1	27	178	34	15	54	0.0
27 NOV 1984	20:32:9	259	50	10	52	113	20	42	88	0.0
18 NOV 1984	10:44:23	260	87	3	27	135	20	24	50	0.0
19 NOV 1984	12:21:15	261	48	20	101	230	51	19	102	0.0
29 NOV 1984	16:14:42	262	42	8	35	262	42	8	35	.1
28 NOV 1984	16:14:28	264	38	12	48	193	29	18	55	4.4
18 NOV 1984	13:43:16	265	48	10	50	232	99	5	52	0.0
28 NOV 1984	3:53:47	265	26	34	93	128	26	38	104	0.0
29 NOV 1984	20:2:12	265	40	31	130	196	46	30	145	3.7
28 NOV 1984	13:16:38	266	58	12	73	253	81	11	105	3.5
29 NOV 1984	16:1:14	266	36	15	57	52	14	15	66	.6

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
27 NOV 1984	22:36:27	267	30	22	69	263	28	24	71	0.0
18 NOV 1984	14:50:58	268	27	17	48	267	58	11	67	0.0
16 NOV 1984	13:1:51	269	64	6	40	131	15	40	63	0.0
28 NOV 1984	16:1:2	269	49	11	57	269	49	11	57	1.2
18 NOV 1984	14:54:1	270	29	30	91	179	40	27	113	0.0
18 NOV 1984	13:10:51	271	25	31	81	248	27	32	91	0.0
19 NOV 1984	14:6:30	272	26	17	46	178	19	30	60	0.0
27 NOV 1984	20:1:50	272	55	7	40	214	48	9	45	0.0
28 NOV 1984	16:14:59	274	99	11	114	217	36	42	159	5.4
1 DEC 1984	16:51:29	274	49	12	62	234	41	17	73	4.3
29 NOV 1984	10:15:16	275	75	20	157	275	75	20	157	6.7
18 NOV 1984	10:42:3	277	76	4	32	108	34	22	78	0.0
29 NOV 1984	19:59:58	277	60	6	38	277	60	6	38	.8
28 NOV 1984	8:39:1	278	72	11	83	223	31	26	85	.2
29 NOV 1984	19:29:1	278	51	22	118	240	82	14	120	4.1
29 NOV 1984	20:31:36	279	71	11	82	129	24	39	98	.1
29 NOV 1984	20:25:53	282	106	5	56	282	106	5	56	.2
18 NOV 1984	13:48:4	283	36	10	38	89	25	19	50	0.0
28 NOV 1984	22:23:11	289	36	27	102	231	51	30	161	0.0
29 NOV 1984	20:4:38	290	67	20	141	290	67	20	141	.7
29 NOV 1984	20:38:59	291	168	2	35	117	15	42	66	1.8
18 NOV 1984	13:1:43	292	36	17	64	144	28	35	103	0.0
26 NOV 1984	3:5:57	292	31	33	107	292	31	33	107	0.0
29 NOV 1984	19:43:31	293	32	36	121	293	32	36	121	1.3
29 NOV 1984	18:48:54	294	34	39	139	294	34	39	139	3.5
18 NOV 1984	13:11:18	297	31	24	78	202	38	29	116	0.0
29 NOV 1984	20:3:40	297	34	12	43	293	36	12	45	.4
29 NOV 1984	10:17:56	298	53	23	128	277	67	19	134	6.1
28 NOV 1984	6:0:6	299	30	21	66	172	26	37	101	.1
18 NOV 1984	13:46:48	303	42	14	62	69	17	39	70	0.0
18 NOV 1984	13:47:2	303	80	9	76	222	27	37	105	0.0
28 NOV 1984	5:49:43	304	34	14	50	134	32	20	67	4.2
28 NOV 1984	8:47:10	305	61	23	147	279	49	30	154	0.0
1 DEC 1984	13:27:19	305	24	32	81	305	24	32	81	1.4
28 NOV 1984	5:49:48	306	130	3	41	189	44	27	125	3.9
28 NOV 1984	8:50:9	306	31	40	130	281	32	39	131	0.0
29 NOV 1984	12:45:3	306	306	1	32	224	15	41	65	6.4
29 NOV 1984	18:34:58	306	29	33	100	197	29	35	106	6.0
28 NOV 1984	10:32:31	308	69	6	43	52	12	38	48	0.0
28 NOV 1984	6:1:15	311	216	2	45	233	61	20	128	1.8
29 NOV 1984	19:52:27	311	35	14	51	114	19	27	54	1.8
28 NOV 1984	2:22:48	312	33	13	45	276	43	14	63	0.0
29 NOV 1984	8:56:4	313	63	23	152	226	67	27	190	0.0
28 NOV 1984	7:47:14	314	39	23	94	314	39	23	94	3.8
29 NOV 1984	7:47:30	314	43	21	95	276	37	36	140	2.9
29 NOV 1984	8:39:30	314	117	3	37	314	117	3	37	5.3
28 NOV 1984	8:7:45	316	30	36	113	316	30	36	113	2.3
19 NOV 1984	13:31:57	318	42	15	66	267	45	14	66	0.0
27 NOV 1984	21:34:10	321	321	1	34	297	76	5	40	0.0
28 NOV 1984	8:15:40	321	26	40	109	230	29	41	109	0.0

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	8:55:9	321	37	29	113	173	53	23	128	0.0
29 NOV 1984	19:25:54	322	40	20	84	269	33	38	132	5.1
1 DEC 1984	22:56:19	322	63	27	178	258	57	37	221	2.7
1 DEC 1984	14:20:31	323	46	12	58	304	43	19	86	.1
18 NOV 1984	13:17:28	325	134	3	42	325	134	3	42	0.0
28 NOV 1984	18:48:46	326	59	11	68	316	65	10	68	41.5
28 NOV 1984	8:46:9	327	37	33	128	292	35	38	140	0.0
18 NOV 1984	14:45:46	328	42	12	53	328	42	12	53	0.0
28 NOV 1984	5:46:44	331	40	31	130	260	44	30	138	0.0
18 NOV 1984	13:57:9	332	59	21	130	332	59	21	130	0.0
28 NOV 1984	2:5:18	332	35	27	99	260	33	29	100	0.0
29 NOV 1984	19:45:51	332	21	38	84	332	21	38	84	.3
29 NOV 1984	20:2:41	332	25	29	76	301	89	10	93	.6
28 NOV 1984	5:59:31	333	35	32	118	144	34	37	132	2.3
18 NOV 1984	10:40:56	335	59	11	68	310	57	12	72	0.0
27 NOV 1984	22:6:9	335	335	1	35	320	35	11	40	0.0
29 NOV 1984	7:54:32	335	54	18	102	174	52	35	191	1.9
28 NOV 1984	13:13:19	335	28	39	115	335	28	39	115	.6
29 NOV 1984	12:54:35	335	190	3	60	335	190	3	60	0.0
29 NOV 1984	19:3:40	336	37	41	159	336	37	41	159	.1
19 NOV 1984	12:21:25	338	86	6	54	180	36	18	68	0.0
28 NOV 1984	8:46:14	338	44	40	185	338	44	40	185	0.0
29 NOV 1984	16:5:37	338	56	29	170	314	57	31	185	1.6
27 NOV 1984	21:49:8	339	62	11	72	339	62	11	72	0.0
29 NOV 1984	10:21:3	339	68	12	86	243	59	14	101	2.5
28 NOV 1984	6:1:5	340	52	20	109	336	46	34	164	3.7
28 NOV 1984	18:6:37	340	58	14	85	340	58	14	85	1.7
28 NOV 1984	8:41:31	342	44	30	138	263	36	37	140	2.3
29 NOV 1984	14:5:10	343	60	10	63	291	28	26	76	1.9
29 NOV 1984	18:23:54	343	37	35	136	255	49	34	175	.3
28 NOV 1984	6:0:11	344	42	29	128	243	39	41	166	2.8
28 NOV 1984	19:18:55	344	44	14	65	344	44	14	65	0.0
28 NOV 1984	5:58:46	345	81	16	136	275	66	24	166	2.6
29 NOV 1984	20:3:9	345	126	4	53	274	45	17	80	4.8
28 NOV 1984	9:12:28	346	51	36	193	346	51	36	193	0.0
29 NOV 1984	16:1:43	347	42	14	62	205	68	13	93	5.2
29 NOV 1984	20:24:43	347	115	4	48	272	27	20	67	2.8
19 NOV 1984	14:5:56	348	46	9	43	348	46	9	43	0.0
18 NOV 1984	12:15:30	349	245	3	77	310	192	4	81	0.0
28 NOV 1984	17:45:21	349	349	1	37	349	349	1	37	3.9
29 NOV 1984	21:10:26	349	98	7	72	303	34	22	78	1.3
19 NOV 1984	14:6:37	350	40	21	88	350	40	21	88	0.0
18 NOV 1984	10:38:51	351	30	18	57	188	43	17	77	0.0
18 NOV 1984	10:40:35	352	37	31	120	352	37	31	120	0.0
28 NOV 1984	8:1:29	352	32	18	60	352	32	18	60	2.4
29 NOV 1984	16:54:16	354	67	11	77	354	67	11	77	3.6
28 NOV 1984	8:30:59	356	44	23	106	354	37	30	116	3.6
29 NOV 1984	8:45:33	356	30	43	135	254	42	39	172	0.0
29 NOV 1984	7:55:4	361	88	17	157	361	88	17	157	1.3
28 NOV 1984	17:9:7	365	34	15	94	365	34	15	94	2.4

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
19 NOV 1984	12:25:59	367	41	26	112	367	41	26	112	0.0
29 NOV 1984	10:18:45	367	40	35	147	337	46	32	154	2.3
28 NOV 1984	13:50:0	369	23	22	53	369	23	22	53	5.7
28 NOV 1984	8:17:46	372	38	24	96	265	32	38	128	4.7
18 NOV 1984	14:50:47	373	36	42	159	373	36	42	159	0.0
28 NOV 1984	8:7:21	374	35	34	125	180	41	31	133	.1
28 NOV 1984	16:5:57	376	46	12	58	225	62	12	78	.2
28 NOV 1984	20:53:50	376	38	34	136	337	43	31	140	0.0
28 NOV 1984	19:19:18	377	50	15	79	335	54	18	102	0.0
29 NOV 1984	10:15:41	377	31	26	85	370	32	30	101	3.1
1 DEC 1984	21:5:5	377	44	24	111	252	59	21	130	.5
28 NOV 1984	8:51:22	379	42	42	185	199	43	42	189	0.0
29 NOV 1984	3:56:15	379	145	4	61	296	30	27	85	.8
29 NOV 1984	1:54:52	380	188	3	59	229	25	43	113	0.0
27 NOV 1984	18:41:11	383	86	5	45	294	22	27	62	0.0
28 NOV 1984	18:18:9	383	26	34	93	299	29	34	100	1.7
28 NOV 1984	8:49:29	386	56	28	165	386	56	28	165	0.0
28 NOV 1984	8:0:51	387	41	12	52	258	61	16	102	.3
29 NOV 1984	1:54:13	387	69	15	109	300	71	18	134	0.0
29 NOV 1984	9:10:57	388	41	40	172	388	41	40	172	0.0
28 NOV 1984	14:27:32	388	34	32	114	388	34	32	114	.1
29 NOV 1984	2:14:20	388	42	30	132	316	58	23	140	0.0
29 NOV 1984	19:11:36	388	34	33	118	388	34	33	118	.1
19 NOV 1984	12:35:17	390	48	9	45	390	48	9	45	0.0
29 NOV 1984	2:0:26	392	42	27	119	196	56	29	170	0.0
29 NOV 1984	22:15:47	392	40	20	84	366	43	32	144	.2
29 NOV 1984	18:46:43	393	60	19	120	340	37	40	155	6.7
1 DEC 1984	22:43:55	396	148	6	93	337	139	7	102	3.7
18 NOV 1984	14:28:41	398	64	9	60	317	71	19	142	0.0
18 NOV 1984	14:15:43	399	36	38	144	399	36	38	144	0.0
29 NOV 1984	20:17:26	399	87	11	100	196	31	48	156	.1
29 NOV 1984	8:0:44	401	176	3	55	210	29	20	61	3.0
28 NOV 1984	8:31:39	402	34	15	54	401	40	13	55	3.0
29 NOV 1984	10:18:34	402	67	29	204	402	67	29	204	.1
29 NOV 1984	20:23:33	402	215	3	68	366	336	2	71	2.2
28 NOV 1984	18:47:47	403	43	19	86	403	43	19	86	1.7
29 NOV 1984	12:55:41	403	271	2	57	302	39	21	86	1.7
29 NOV 1984	23:20:55	404	36	30	113	404	36	30	113	0.0
19 NOV 1984	13:32:26	406	30	46	145	406	30	46	145	0.0
28 NOV 1984	19:17:23	406	406	1	43	271	42	15	66	.1
28 NOV 1984	18:9:53	407	45	18	85	407	45	18	85	2.2
29 NOV 1984	20:23:39	407	72	13	98	334	34	36	128	2.0
28 NOV 1984	8:57:53	409	346	2	73	409	346	2	73	0.0
27 NOV 1984	20:19:24	410	56	10	59	386	41	14	60	0.0
28 NOV 1984	8:24:56	410	36	36	136	265	48	29	146	3.2
28 NOV 1984	18:40:7	413	69	10	72	413	69	10	72	6.2
28 NOV 1984	8:24:50	415	80	19	159	231	69	25	161	2.6
28 NOV 1984	8:31:8	415	61	18	115	415	61	18	115	3.4
28 NOV 1984	8:53:27	415	29	25	76	415	29	25	76	0.0
29 NOV 1984	17:45:15	415	415	1	44	415	415	1	44	1.6

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	20:59:50	420	59	26	161	420	59	26	161	0.0
18 NOV 1984	14:15:33	424	162	3	51	285	100	13	136	0.0
28 NOV 1984	8:42:39	424	61	20	128	360	54	26	147	2.9
28 NOV 1984	19:25:25	424	37	26	101	340	43	32	144	0.0
28 NOV 1984	5:58:41	427	43	44	198	391	50	42	220	.2
28 NOV 1984	9:16:2	427	73	24	184	355	99	21	218	0.0
28 NOV 1984	17:2:0	428	80	10	84	428	80	10	84	1.3
28 NOV 1984	20:5:5	429	77	11	89	429	77	11	89	0.0
29 NOV 1984	1:53:58	432	44	31	143	432	44	31	143	0.0
28 NOV 1984	18:30:37	433	433	1	45	327	37	19	74	17.8
29 NOV 1984	2:13:9	434	50	29	152	434	50	29	152	0.0
29 NOV 1984	20:52:44	435	76	10	80	195	42	20	88	4.5
1 DEC 1984	13:55:15	436	45	14	66	350	72	9	68	40.4
29 NOV 1984	20:51:47	439	88	18	166	389	79	21	174	.1
28 NOV 1984	8:59:29	443	53	22	122	297	45	32	151	0.0
28 NOV 1984	19:26:11	447	77	16	129	447	77	16	129	0.0
18 NOV 1984	14:18:14	453	58	34	207	351	63	33	218	0.0
28 NOV 1984	19:0:2	453	49	17	87	437	37	23	89	2.1
29 NOV 1984	2:13:41	453	453	1	48	241	66	21	145	0.0
28 NOV 1984	8:45:50	457	36	37	140	457	36	37	140	0.0
1 DEC 1984	22:35:26	458	40	45	189	458	40	45	189	.2
29 NOV 1984	20:5:57	462	99	6	62	153	24	37	93	1.2
29 NOV 1984	10:12:4	469	167	5	98	433	147	6	93	2.9
28 NOV 1984	5:41:3	470	71	21	156	463	62	25	163	0.0
18 NOV 1984	12:59:21	474	22	45	104	474	22	45	104	0.0
28 NOV 1984	14:49:46	476	64	9	60	173	41	26	112	4.0
28 NOV 1984	8:46:45	478	478	1	50	78	19	36	72	0.0
28 NOV 1984	18:9:41	478	53	22	122	246	63	29	192	2.8
29 NOV 1984	21:55:19	478	67	22	155	478	67	22	155	3.8
28 NOV 1984	5:59:23	479	43	29	131	371	43	35	156	2.6
28 NOV 1984	8:54:48	479	179	7	131	445	87	22	201	0.0
28 NOV 1984	3:21:22	486	486	1	51	334	39	17	70	0.0
28 NOV 1984	19:20:56	487	65	15	102	236	68	27	193	0.0
1 DEC 1984	14:15:34	499	38	18	72	499	38	18	72	1.5
28 NOV 1984	8:21:23	501	25	32	84	501	25	32	84	2.0
29 NOV 1984	22:16:32	503	60	25	157	342	74	23	179	3.3
1 DEC 1984	22:49:56	506	114	8	96	506	114	8	96	2.8
28 NOV 1984	18:26:51	507	102	9	96	450	112	10	118	4.2
29 NOV 1984	20:39:54	509	46	36	174	415	44	38	175	2.3
29 NOV 1984	20:18:56	510	68	26	185	510	68	26	185	6.2
28 NOV 1984	16:35:17	511	74	11	85	503	58	15	91	1.7
29 NOV 1984	19:50:2	515	30	34	107	515	30	34	107	0.0
29 NOV 1984	14:14:24	519	193	4	64	406	33	21	73	6.2
19 NOV 1984	14:7:4	520	29	35	106	520	29	35	106	0.0
28 NOV 1984	8:43:3	520	73	23	176	456	76	24	191	1.3
29 NOV 1984	2:9:33	523	57	24	144	359	67	23	162	0.0
28 NOV 1984	6:0:36	524	30	24	76	524	30	24	76	2.2
26 NOV 1984	16:10:20	527	126	7	83	527	126	7	83	.1
29 NOV 1984	1:55:21	531	43	43	194	531	43	43	194	0.0
29 NOV 1984	7:54:29	537	40	30	129	537	40	30	129	1.3

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
18 NOV 1984	13:3:37	538	30	39	123	474	33	38	132	0.0
28 NOV 1984	19:22:30	541	64	22	148	350	38	38	151	0.0
29 NOV 1984	20:50:52	541	219	9	207	443	259	8	217	.2
28 NOV 1984	19:22:48	544	46	32	154	544	46	32	154	0.0
1 DEC 1984	22:50:5	554	31	43	140	451	28	48	141	1.9
28 NOV 1984	19:7:24	556	65	19	130	487	62	27	176	1.1
28 NOV 1984	9:0:31	558	68	16	114	289	70	16	118	0.0
29 NOV 1984	21:28:17	559	87	8	73	222	24	36	91	2.6
28 NOV 1984	8:46:35	560	105	15	165	398	82	21	181	0.0
28 NOV 1984	19:33:15	561	35	39	143	495	41	35	151	0.0
1 DEC 1984	23:45:35	562	275	5	144	416	73	22	168	3.5
1 DEC 1984	18:36:35	583	167	4	70	464	28	32	94	1.2
1 DEC 1984	14:16:16	589	133	10	140	576	133	11	153	3.5
28 NOV 1984	8:54:57	591	43	28	126	291	63	22	145	0.0
29 NOV 1984	20:40:52	592	592	1	62	575	225	3	71	.2
29 NOV 1984	19:30:33	599	250	5	131	599	250	5	131	4.2
28 NOV 1984	18:58:33	610	125	7	92	481	108	11	125	1.4
29 NOV 1984	21:26:53	625	89	18	168	267	72	23	174	5.6
28 NOV 1984	18:39:51	634	634	1	67	563	64	11	74	2.7
28 NOV 1984	8:43:23	656	77	20	162	414	101	20	212	0.0
29 NOV 1984	20:35:31	659	59	24	149	639	69	30	217	1.0
29 NOV 1984	10:12:37	666	137	10	144	275	58	43	262	.5
1 DEC 1984	14:15:42	687	68	15	107	256	27	39	110	4.4
29 NOV 1984	22:16:27	719	56	41	241	699	59	39	241	4.9
28 NOV 1984	5:46:35	729	79	22	182	579	69	35	253	0.0
29 NOV 1984	22:56:23	729	56	46	270	729	56	46	270	3.0
25 NOV 1984	8:44:48	731	93	14	137	519	227	6	143	0.0
29 NOV 1984	12:52:40	733	53	33	183	733	53	33	183	1.2
28 NOV 1984	18:26:46	775	170	12	214	775	170	12	214	.5
29 NOV 1984	20:35:53	775	206	5	108	506	45	37	175	2.4
28 NOV 1984	19:26:2	785	785	1	82	717	184	19	367	0.0
28 NOV 1984	18:49:50	793	97	14	142	570	158	10	166	2.6
29 NOV 1984	14:35:42	796	293	4	123	554	145	12	183	3.5
28 NOV 1984	18:50:16	811	95	14	140	749	74	18	140	.7
29 NOV 1984	19:13:3	818	97	33	335	630	83	43	374	1.4
28 NOV 1984	8:7:29	838	260	8	218	673	76	39	311	7.5
28 NOV 1984	19:19:4	1041	399	3	126	628	63	27	178	0.0

APPENDIX B

SUMMARY OF MEASURED DATA RANKED BY PEAK FORCE DURING EACH EVENT

KEY:

- PM1 - Maximum single sub-panel pressure (psi)
- PA1 - Average pressure over the contact area at the time of peak pressure (psi)
- A1 - Contact area at the time of peak pressure (sub-panels)
- F1 - Total panel force at the time of peak pressure (LT)
- PM2 - Maximum single sub-panel force (psi)
- PA2 - Average pressure over the contact area at the time of peak force (psi)
- A2 - Contact area at the time of peak force (sub-panels)
- F2 - Peak total panel force (LT)
- VEL - Ship velocity at impact

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
1 DEC 1984	13:49:38	111	111	1	12	55	7	16	12	.7
1 DEC 1984	13:52:11	145	78	2	16	142	14	13	19	0.0
18 NOV 1984	15:15:28	90	31	6	20	36	12	17	21	0.0
29 NOV 1984	19:59:7	139	25	7	19	25	6	34	21	2.2
1 DEC 1984	15:13:59	139	53	3	17	94	25	8	21	1.4
18 NOV 1984	13:1:33	150	14	15	22	150	14	15	22	0.0
27 NOV 1984	15:20:46	93	15	14	22	93	15	14	22	0.0
1 DEC 1984	13:53:32	109	13	16	22	109	13	16	22	2.3
1 DEC 1984	13:37:17	175	22	10	23	175	22	10	23	7.0
1 DEC 1984	13:50:30	199	199	1	21	184	24	9	23	.1
18 NOV 1984	10:32:31	135	35	5	18	87	21	11	24	0.0
27 NOV 1984	20:10:37	202	202	1	21	173	17	14	25	0.0
18 NOV 1984	13:7:39	126	31	5	16	81	20	13	27	0.0
18 NOV 1984	13:53:10	134	12	21	26	128	15	17	27	0.0
18 NOV 1984	15:8:27	87	11	23	27	87	11	23	27	0.0
27 NOV 1984	21:4:59	235	64	4	27	235	64	4	27	0.0
27 NOV 1984	17:14:23	130	130	1	14	37	9	31	29	0.0
1 DEC 1984	13:50:20	117	20	12	25	97	11	25	29	.1
1 DEC 1984	13:55:4	104	104	1	11	41	7	42	31	1.9
18 NOV 1984	13:58:34	195	84	3	26	162	28	11	32	0.0
18 NOV 1984	15:0:8	91	15	10	16	24	9	34	32	0.0
27 NOV 1984	18:49:58	195	44	6	28	136	38	8	32	0.0
18 NOV 1984	14:49:38	254	60	5	31	214	78	4	33	0.0
1 DEC 1984	14:24:14	146	21	9	20	115	79	4	33	2.3
18 NOV 1984	14:52:0	187	43	7	32	71	9	36	34	0.0
27 NOV 1984	21:39:0	247	41	8	34	247	41	8	34	0.0
1 DEC 1984	13:36:51	156	43	4	18	79	16	20	34	3.0
28 NOV 1984	16:14:42	262	42	8	35	262	42	8	35	.1
29 NOV 1984	19:54:9	236	26	13	35	236	26	13	35	1.0
1 DEC 1984	13:54:48	127	20	14	29	105	13	26	35	.1
1 DEC 1984	15:13:51	228	33	9	36	228	38	9	36	1.9
18 NOV 1984	10:39:56	136	24	17	33	82	14	25	37	0.0
28 NOV 1984	3:42:40	170	36	5	19	39	10	35	37	0.0
28 NOV 1984	8:39:30	314	117	3	37	314	117	3	37	5.3
28 NOV 1984	17:45:21	349	349	1	37	349	349	1	37	3.8
1 DEC 1984	15:14:9	249	52	8	33	237	17	21	37	1.1
18 NOV 1984	14:53:46	189	18	14	29	70	10	38	38	0.0
29 NOV 1984	19:53:58	277	60	6	38	277	60	6	38	.8
1 DEC 1984	13:8:51	140	33	7	24	63	9	40	38	4.5
18 NOV 1984	10:38:37	190	46	7	34	46	12	31	39	0.0
27 NOV 1984	21:34:10	321	321	1	34	297	76	9	40	0.0
27 NOV 1984	22:6:9	335	335	1	35	320	35	11	40	0.0
28 NOV 1984	0:34:20	234	21	18	40	234	21	18	40	0.0
29 NOV 1984	20:1:40	227	67	4	28	69	13	29	40	2.4
18 NOV 1984	15:8:11	165	14	28	41	165	14	28	41	0.0
1 DEC 1984	13:20:10	110	64	2	13	60	15	26	41	7.3
18 NOV 1984	13:17:28	325	134	3	42	325	134	3	42	0.0
1 DEC 1984	13:36:13	198	70	3	22	64	10	40	42	2.7
19 NOV 1984	14:5:56	348	46	9	43	348	46	9	43	0.0
1 DEC 1984	13:39:9	135	34	9	32	61	12	34	43	-.2

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	17:45:45	418	418	1	44	418	418	1	44	1.6
1 DEC 1984	13:36:4	149	15	13	20	61	13	32	44	3.1
1 DEC 1984	15:12:15	198	68	6	43	140	30	14	44	1.8
19 NOV 1984	12:35:17	390	48	9	45	390	48	9	45	0.0
27 NOV 1984	20:1:50	272	55	7	40	214	48	9	45	0.0
29 NOV 1984	19:8:1	248	43	10	45	248	43	10	45	3.4
29 NOV 1984	20:3:40	297	34	12	43	293	36	12	45	.4
18 NOV 1984	14:53:23	229	44	10	46	229	44	10	46	0.0
27 NOV 1984	20:1:45	200	27	16	45	87	25	18	47	0.0
28 NOV 1984	10:32:31	308	69	6	43	52	12	38	48	0.0
1 DEC 1984	15:2:55	162	48	5	25	83	15	31	49	2.6
18 NOV 1984	10:44:23	260	87	3	27	135	20	24	50	0.0
18 NOV 1984	13:48:4	283	36	10	38	89	25	19	50	0.0
1 DEC 1984	14:14:22	210	74	3	23	70	13	37	50	.9
18 NOV 1984	13:7:26	242	152	3	48	105	15	33	52	0.0
18 NOV 1984	13:11:7	236	35	11	40	77	12	41	52	0.0
18 NOV 1984	13:43:16	265	48	10	50	232	99	5	52	0.0
18 NOV 1984	14:45:46	328	42	12	53	328	42	12	53	0.0
28 NOV 1984	13:50:0	369	23	22	53	369	23	22	53	5.7
18 NOV 1984	13:49:27	249	20	17	36	177	64	8	54	0.0
27 NOV 1984	20:19:31	258	258	1	27	178	34	15	54	0.0
28 NOV 1984	17:9:7	365	34	15	54	365	34	15	54	2.4
29 NOV 1984	19:52:27	311	35	14	51	114	19	27	54	1.9
1 DEC 1984	13:40:3	182	76	3	24	111	16	32	54	5.1
27 NOV 1984	20:10:16	182	95	2	20	152	18	29	55	0.0
28 NOV 1984	8:31:39	402	34	15	54	401	40	13	55	3.0
28 NOV 1984	16:14:28	264	38	12	48	193	29	18	55	4.4
29 NOV 1984	20:25:53	282	106	5	56	282	106	5	56	.2
1 DEC 1984	14:14:41	254	31	12	39	197	14	38	56	2.0
18 NOV 1984	13:46:38	224	29	14	41	106	13	42	57	0.0
28 NOV 1984	16:1:2	269	49	11	57	269	49	11	57	1.2
29 NOV 1984	20:24:43	347	115	4	48	272	27	20	57	2.3
18 NOV 1984	10:41:22	145	145	1	15	117	61	9	58	0.0
27 NOV 1984	18:32:31	165	36	7	26	102	20	28	59	0.0
28 NOV 1984	3:59:43	245	17	33	58	245	17	33	58	0.0
28 NOV 1984	5:58:52	162	39	9	37	114	14	40	58	2.5
19 NOV 1984	14:6:30	272	26	17	46	178	19	30	60	0.0
27 NOV 1984	20:19:24	410	56	10	58	386	41	14	60	0.0
28 NOV 1984	4:29:31	186	78	5	41	155	32	18	60	0.0
26 NOV 1984	8:1:29	352	32	18	60	352	32	18	60	2.4
29 NOV 1984	12:54:35	335	190	3	60	335	190	3	60	0.0
29 NOV 1984	19:32:6	253	40	12	50	62	15	38	60	3.2
28 NOV 1984	8:0:44	401	176	3	58	210	29	20	61	3.3
27 NOV 1984	18:41:11	383	86	5	45	284	22	27	62	0.0
28 NOV 1984	4:29:0	203	203	1	21	156	33	18	62	0.0
18 NOV 1984	13:1:51	269	64	6	40	131	15	40	63	0.0
28 NOV 1984	2:22:48	312	33	13	49	276	43	14	63	0.0
19 NOV 1984	12:26:22	197	22	23	66	197	22	29	66	0.0
28 NOV 1984	3:14:10	248	140	2	23	109	23	31	66	0.0
29 NOV 1984	12:49:2	306	306	1	30	224	16	41	66	6.1

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	19:18:55	344	44	14	65	344	44	14	65	0.0
18 NOV 1984	10:35:25	147	44	14	65	137	45	14	66	0.0
19 NOV 1984	13:31:57	318	42	15	66	267	45	14	66	0.0
28 NOV 1984	16:1:14	266	36	15	57	62	14	45	66	.6
28 NOV 1984	19:17:23	406	406	1	43	271	42	15	66	.1
29 NOV 1984	20:38:59	291	168	2	35	117	15	42	66	1.8
18 NOV 1984	14:50:58	268	27	17	48	267	58	11	67	0.0
27 NOV 1984	22:17:1	238	192	2	40	201	40	16	67	0.0
28 NOV 1984	5:49:43	304	34	14	50	134	32	20	67	4.2
19 NOV 1984	12:21:25	338	86	6	54	180	36	18	68	0.0
28 NOV 1984	18:48:46	326	59	11	68	316	65	10	68	41.5
1 DEC 1984	13:55:15	436	45	14	66	350	72	9	68	40.4
18 NOV 1984	13:17:50	234	24	25	63	179	41	16	69	0.0
18 NOV 1984	13:46:48	303	42	14	62	69	17	39	70	0.0
28 NOV 1984	3:21:22	486	486	1	51	334	39	17	70	0.0
27 NOV 1984	22:36:27	267	30	22	69	263	28	24	71	0.0
29 NOV 1984	20:23:33	402	215	3	68	366	336	2	71	2.2
29 NOV 1984	20:40:52	592	592	1	62	575	225	3	71	.2
18 NOV 1984	10:40:56	335	59	11	68	310	57	12	72	0.0
27 NOV 1984	21:49:8	339	62	11	72	339	62	11	72	0.0
28 NOV 1984	8:46:45	478	478	1	50	78	19	36	72	0.0
28 NOV 1984	18:40:7	413	69	10	72	413	69	10	72	6.2
1 DEC 1984	14:15:34	499	38	18	72	499	38	18	72	1.5
29 NOV 1984	3:20:38	297	29	20	61	253	33	21	73	0.0
28 NOV 1984	8:57:53	409	346	2	73	409	346	2	73	0.0
29 NOV 1984	14:14:24	519	153	4	64	406	33	21	73	6.2
1 DEC 1984	16:51:29	274	49	12	62	234	41	17	73	4.3
28 NOV 1984	18:30:37	433	433	1	45	327	37	19	74	17.8
28 NOV 1984	18:39:51	634	634	1	67	563	64	11	74	2.7
18 NOV 1984	14:0:11	203	51	14	75	193	45	16	76	0.0
28 NOV 1984	6:0:36	524	30	24	76	524	30	24	76	2.2
28 NOV 1984	8:53:27	415	29	25	76	415	29	25	76	0.0
29 NOV 1984	14:5:10	343	60	10	63	291	28	26	76	1.9
18 NOV 1984	10:38:51	351	30	18	57	186	43	17	77	0.0
28 NOV 1984	16:54:16	354	67	11	77	354	67	11	77	3.6
18 NOV 1984	10:42:3	277	76	4	32	108	34	22	78	0.0
28 NOV 1984	16:5:57	376	46	12	58	225	62	12	78	.2
29 NOV 1984	21:10:26	349	98	7	72	303	34	22	78	1.3
29 NOV 1984	20:3:9	345	126	4	53	274	45	17	80	4.8
18 NOV 1984	12:15:30	349	245	3	77	310	192	4	81	0.0
1 DEC 1984	13:27:19	305	24	32	81	305	24	32	81	1.4
28 NOV 1984	4:2:17	201	19	40	80	184	22	36	83	0.0
28 NOV 1984	8:21:23	501	25	32	84	501	25	32	84	2.0
28 NOV 1984	17:2:0	428	80	10	64	428	80	10	84	1.3
29 NOV 1984	19:45:51	332	21	38	84	332	21	38	84	.3
28 NOV 1984	3:7:12	212	25	29	76	177	27	30	85	0.0
28 NOV 1984	8:39:1	278	72	11	83	223	31	26	85	.2
28 NOV 1984	18:6:37	340	98	14	85	340	98	14	85	1.7
28 NOV 1984	18:9:53	407	45	18	85	407	45	18	85	2.2
29 NOV 1984	3:56:16	279	149	4	61	236	30	27	85	.3

DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
28 NOV 1984	18:47:47	403	43	19	86	403	43	19	86	1.7
29 NOV 1984	12:55:41	403	271	2	57	302	39	21	86	1.7
1 DEC 1984	14:20:31	323	46	12	58	304	43	19	86	.1
18 NOV 1984	10:34:7	226	64	12	81	214	75	11	87	0.0
18 NOV 1984	13:49:12	233	62	6	39	179	42	20	88	0.0
19 NOV 1984	14:6:37	350	40	21	88	350	40	21	88	0.0
27 NOV 1984	20:32:9	259	50	10	52	113	20	42	88	0.0
29 NOV 1984	19:46:50	203	22	38	88	203	22	38	88	.1
29 NOV 1984	20:52:44	435	76	10	80	195	42	20	88	4.5
28 NOV 1984	19:0:2	453	49	17	87	437	37	23	89	2.1
28 NOV 1984	20:5:5	429	77	11	89	429	77	11	89	0.0
18 NOV 1984	13:10:51	271	25	31	81	248	27	32	91	0.0
28 NOV 1984	16:15:11	237	36	24	91	237	36	24	91	4.6
28 NOV 1984	18:35:17	511	74	11	85	503	58	15	91	1.7
29 NOV 1984	21:28:17	559	87	8	73	222	24	36	91	2.6
28 NOV 1984	5:40:53	226	36	19	72	184	35	25	92	0.0
28 NOV 1984	6:0:16	231	46	19	92	231	46	19	92	2.1
28 NOV 1984	16:1:43	347	42	14	62	205	68	13	93	5.2
28 NOV 1984	16:13:20	527	126	7	93	527	126	7	93	.1
29 NOV 1984	10:12:4	469	167	5	88	433	147	6	93	2.9
29 NOV 1984	20:2:41	332	25	29	76	301	89	10	93	.6
29 NOV 1984	20:5:57	462	99	6	62	153	24	37	93	1.2
28 NOV 1984	7:47:14	314	39	23	94	314	39	23	94	3.8
29 NOV 1984	18:44:0	206	22	37	85	142	64	14	94	1.3
1 DEC 1984	18:36:35	583	167	4	70	464	28	32	94	1.2
1 DEC 1984	22:49:58	506	114	8	96	506	114	8	96	2.9
29 NOV 1984	20:31:36	279	71	11	82	129	24	39	98	.1
1 DEC 1984	15:13:45	253	35	24	88	182	24	39	98	2.2
28 NOV 1984	7:49:21	257	27	35	99	257	27	35	99	1.8
28 NOV 1984	2:5:18	332	35	27	99	260	33	29	100	0.0
28 NOV 1984	18:18:9	383	26	34	93	299	28	34	100	1.7
29 NOV 1984	6:0:6	299	30	21	66	172	26	37	101	.1
29 NOV 1984	10:15:41	377	31	26	85	370	32	30	101	3.1
29 NOV 1984	10:21:3	339	68	12	86	243	69	14	101	2.5
18 NOV 1984	10:39:10	152	52	5	27	147	36	27	102	0.0
19 NOV 1984	12:21:15	261	48	20	101	230	51	19	102	0.0
29 NOV 1984	8:0:51	387	41	12	52	258	61	16	102	.3
29 NOV 1984	19:19:18	377	50	15	79	335	54	18	102	0.0
1 DEC 1984	22:43:55	396	148	6	93	337	139	7	102	3.7
18 NOV 1984	13:1:43	292	36	17	64	144	28	35	103	0.0
18 NOV 1984	12:59:21	474	22	45	104	474	22	45	104	0.0
28 NOV 1984	3:53:47	265	26	34	93	128	26	38	104	0.0
18 NOV 1984	13:47:2	303	80	9	76	222	27	37	105	0.0
28 NOV 1984	13:16:38	266	58	12	73	253	91	11	105	3.5
19 NOV 1984	14:7:4	520	29	35	106	520	29	35	106	0.0
29 NOV 1984	18:34:58	306	29	33	100	197	29	35	106	6.0
28 NOV 1984	3:5:57	292	31	33	107	292	31	33	107	0.0
28 NOV 1984	19:52:2	515	30	34	107	515	30	34	107	0.0
1 DEC 1984	14:15:42	527	63	15	107	256	27	39	110	4.4
28 NOV 1984	3:40:29	250	250	1	25	156	40	22	111	0.0

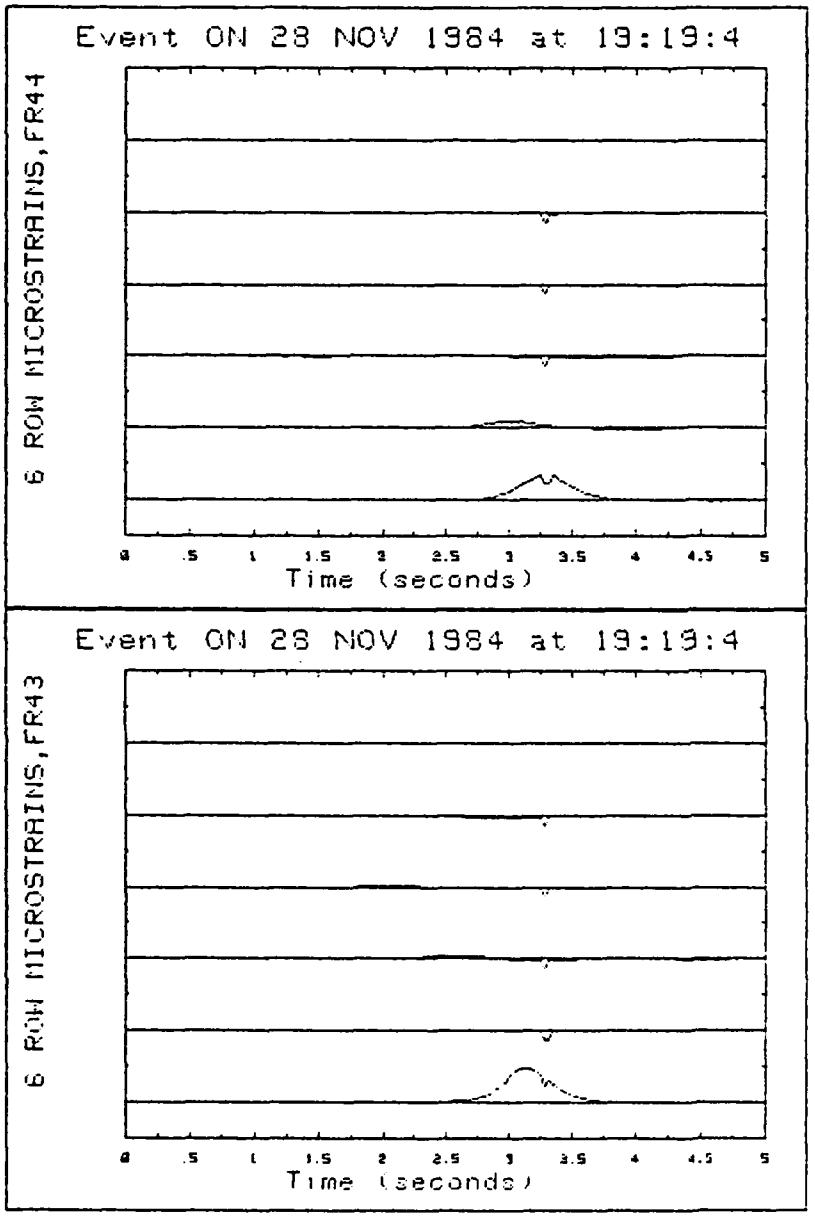
DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
19 NOV 1984	12:25:59	367	41	26	112	367	41	26	112	0.0
28 NOV 1984	14:49:46	476	64	9	60	173	41	26	112	4.0
18 NOV 1984	14:54:1	270	29	30	91	179	40	27	113	0.0
28 NOV 1984	8:7:45	316	30	36	113	316	30	36	113	2.3
28 NOV 1984	23:20:55	404	36	30	113	404	36	30	113	0.0
29 NOV 1984	1:54:52	380	188	3	59	229	25	43	113	0.0
28 NOV 1984	14:27:32	388	34	32	114	388	34	32	114	.1
28 NOV 1984	8:31:8	415	61	18	115	415	61	18	115	3.4
28 NOV 1984	13:13:19	335	28	39	115	335	28	39	115	.6
18 NOV 1984	13:11:18	297	31	24	78	202	38	29	116	0.0
28 NOV 1984	8:30:59	356	44	23	106	354	37	30	116	3.6
29 NOV 1984	18:32:54	224	28	38	112	224	29	38	116	7.0
28 NOV 1984	9:0:31	558	68	16	114	289	70	16	118	0.0
28 NOV 1984	18:26:51	507	102	9	96	450	112	10	118	4.2
29 NOV 1984	19:11:36	388	34	33	118	388	34	33	118	.1
18 NOV 1984	10:40:35	352	37	31	120	352	37	31	120	0.0
29 NOV 1984	19:29:1	278	51	22	118	240	82	14	120	4.1
29 NOV 1984	19:43:31	293	32	36	121	293	32	36	121	1.3
28 NOV 1984	5:49:48	306	130	3	41	189	44	27	125	3.9
28 NOV 1984	8:45:40	321	26	40	109	233	29	41	125	0.0
28 NOV 1984	18:58:33	610	125	7	92	481	108	11	125	1.4
28 NOV 1984	7:54:39	537	40	30	126	537	40	30	126	1.8
18 NOV 1984	10:39:50	250	68	16	114	238	81	15	127	0.0
28 NOV 1984	6:1:15	311	216	2	45	233	61	20	128	1.8
28 NOV 1984	8:17:46	372	38	24	96	265	32	38	128	4.7
28 NOV 1984	8:55:9	321	37	29	113	173	53	23	128	0.0
29 NOV 1984	19:7:24	252	35	33	121	236	36	34	128	.7
29 NOV 1984	20:23:39	407	72	13	98	334	34	36	128	2.0
28 NOV 1984	19:26:11	447	77	16	129	447	77	16	129	0.0
18 NOV 1984	13:57:9	332	59	21	130	332	59	21	130	0.0
1 DEC 1984	21:5:5	377	44	24	111	252	59	21	130	.5
29 NOV 1984	8:50:9	306	31	40	130	291	32	39	131	0.0
29 NOV 1984	19:30:33	599	250	5	131	599	250	5	131	4.2
18 NOV 1984	13:3:37	538	30	39	123	474	33	38	132	0.0
28 NOV 1984	5:59:31	333	35	32	118	144	34	37	132	2.3
29 NOV 1984	19:25:54	322	40	20	84	269	33	38	132	5.1
28 NOV 1984	8:7:21	374	35	34	125	180	41	31	133	.1
29 NOV 1984	1:54:13	387	69	15	109	300	71	18	134	0.0
29 NOV 1984	10:17:56	298	53	23	128	277	67	19	134	6.1
18 NOV 1984	14:15:33	424	162	3	51	285	100	13	136	0.0
29 NOV 1984	19:11:45	254	31	42	137	254	31	42	137	.1
28 NOV 1984	5:46:44	331	40	31	130	260	44	30	138	0.0
28 NOV 1984	5:59:58	235	38	29	116	184	44	30	139	2.8
29 NOV 1984	18:48:54	294	34	39	139	294	34	39	139	3.5
28 NOV 1984	7:47:30	314	43	21	95	276	37	36	140	2.9
28 NOV 1984	8:41:31	342	44	30	138	263	36	37	140	2.3
28 NOV 1984	8:45:50	457	36	37	140	457	36	37	140	0.0
28 NOV 1984	8:46:9	327	37	33	128	292	35	38	140	0.0
28 NOV 1984	18:50:16	911	95	14	140	749	74	18	140	.7
28 NOV 1984	20:42:50	376	38	34	136	337	42	31	140	0.0

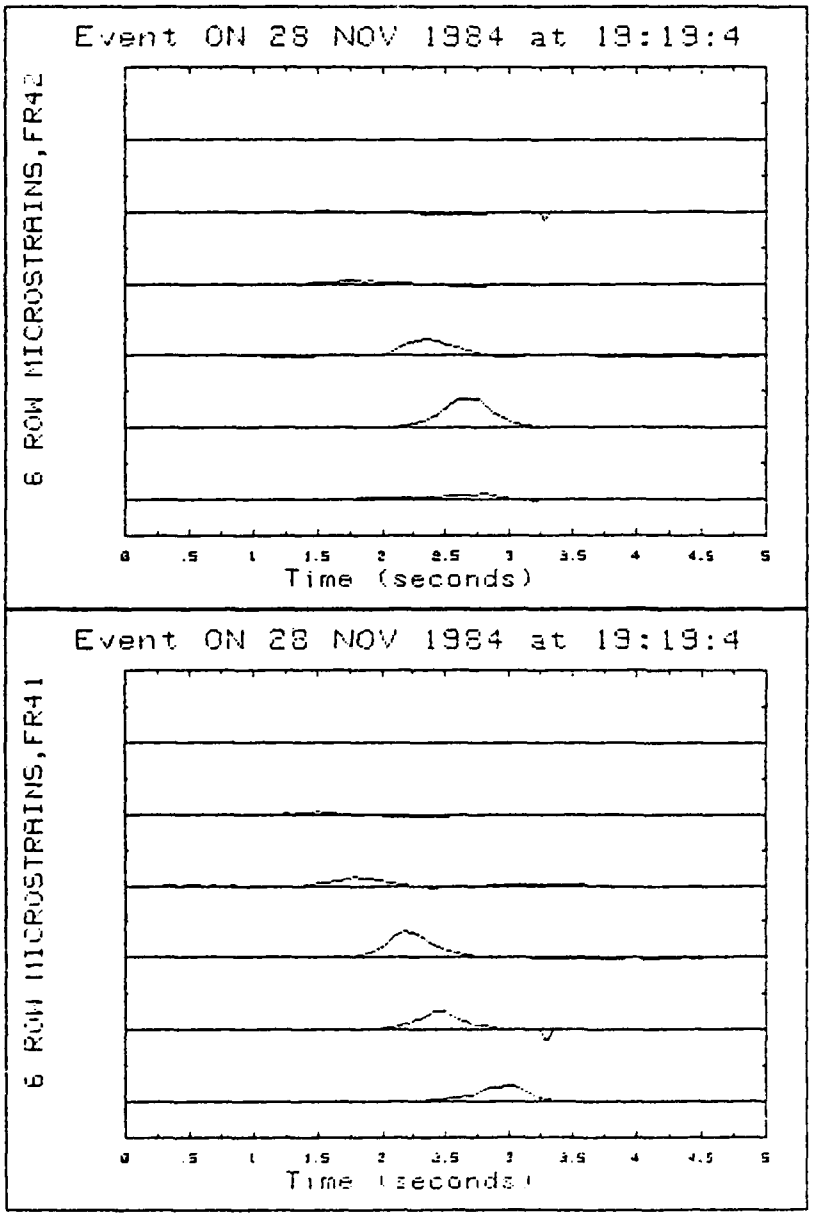
DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
29 NOV 1984	2:14:20	386	42	30	132	316	58	23	140	0.0
29 NOV 1984	20:4:38	290	67	20	141	290	67	20	141	.7
1 DEC 1984	22:50:5	554	31	43	140	451	28	48	141	1.9
18 NOV 1984	14:28:41	398	64	9	60	317	71	19	142	0.0
28 NOV 1984	8:44:48	731	93	14	137	519	227	6	143	0.0
29 NOV 1984	1:53:58	432	44	31	143	432	44	31	143	0.0
18 NOV 1984	14:15:43	399	36	38	144	399	36	38	144	0.0
28 NOV 1984	19:25:25	424	37	26	101	340	43	32	144	0.0
29 NOV 1984	22:15:47	392	40	20	84	366	43	32	144	.2
19 NOV 1984	13:32:26	406	30	46	145	406	30	46	145	0.0
29 NOV 1984	8:54:57	591	43	28	126	291	63	22	145	0.0
29 NOV 1984	2:13:41	453	453	1	48	241	66	21	145	0.0
29 NOV 1984	20:2:12	265	40	31	130	186	46	30	145	3.7
28 NOV 1984	8:24:56	410	36	36	136	265	48	29	146	3.2
28 NOV 1984	8:42:39	424	61	20	128	360	54	26	147	2.9
28 NOV 1984	8:59:28	443	53	22	122	297	45	32	151	0.0
28 NOV 1984	19:22:30	541	64	22	148	350	38	38	151	0.0
28 NOV 1984	19:33:15	561	35	39	143	495	41	35	151	0.0
29 NOV 1984	2:13:9	434	50	29	152	434	50	29	152	0.0
29 NOV 1984	19:49:2	246	31	21	68	187	33	44	152	1.4
1 DEC 1984	14:16:16	589	133	10	140	576	133	11	153	3.5
28 NOV 1984	8:47:10	305	61	23	147	279	49	30	154	0.0
28 NOV 1984	19:22:48	544	46	32	154	544	46	32	154	0.0
29 NOV 1984	10:18:45	367	40	35	147	337	46	32	154	2.3
29 NOV 1984	18:46:43	393	60	19	120	340	37	40	155	6.7
29 NOV 1984	21:55:19	478	67	22	155	478	67	22	155	3.8
29 NOV 1984	20:17:26	399	87	11	100	198	31	48	156	.1
28 NOV 1984	7:55:4	361	88	17	157	361	88	17	157	1.3
29 NOV 1984	10:15:16	275	75	20	157	275	75	20	157	6.7
29 NOV 1984	5:59:23	479	43	29	131	371	43	35	158	2.6
18 NOV 1984	14:50:47	373	36	42	158	373	36	42	159	0.0
28 NOV 1984	16:14:59	274	99	11	114	217	36	42	159	5.4
29 NOV 1984	19:3:40	336	37	41	159	336	37	41	159	.1
28 NOV 1984	20:59:50	420	59	26	161	420	59	26	161	0.0
28 NOV 1984	22:23:11	289	36	27	102	231	51	30	161	0.0
29 NOV 1984	2:9:33	523	57	24	144	359	67	23	162	0.0
28 NOV 1984	5:41:3	470	71	21	156	463	62	25	163	0.0
29 NOV 1984	6:1:5	340	52	20	109	336	46	34	164	3.7
28 NOV 1984	8:49:29	386	56	29	165	366	58	28	165	0.0
28 NOV 1984	5:58:46	345	81	16	136	275	66	24	166	2.5
28 NOV 1984	18:49:50	793	97	14	142	570	158	10	166	2.5
29 NOV 1984	6:0:11	344	42	29	122	243	39	41	168	2.8
1 DEC 1984	23:45:35	562	275	5	144	416	73	22	168	3.5
29 NOV 1984	2:0:26	392	42	27	119	196	56	29	170	0.0
28 NOV 1984	8:45:33	356	30	43	135	254	42	39	172	0.0
29 NOV 1984	9:10:57	388	41	40	172	388	41	40	172	0.0
29 NOV 1984	20:51:47	439	88	18	166	389	79	21	174	.1
29 NOV 1984	21:26:52	525	93	18	168	267	72	23	174	5.6
29 NOV 1984	19:22:54	342	37	35	136	255	49	34	175	.3
29 NOV 1984	20:25:52	775	109	5	109	505	45	37	175	2.1

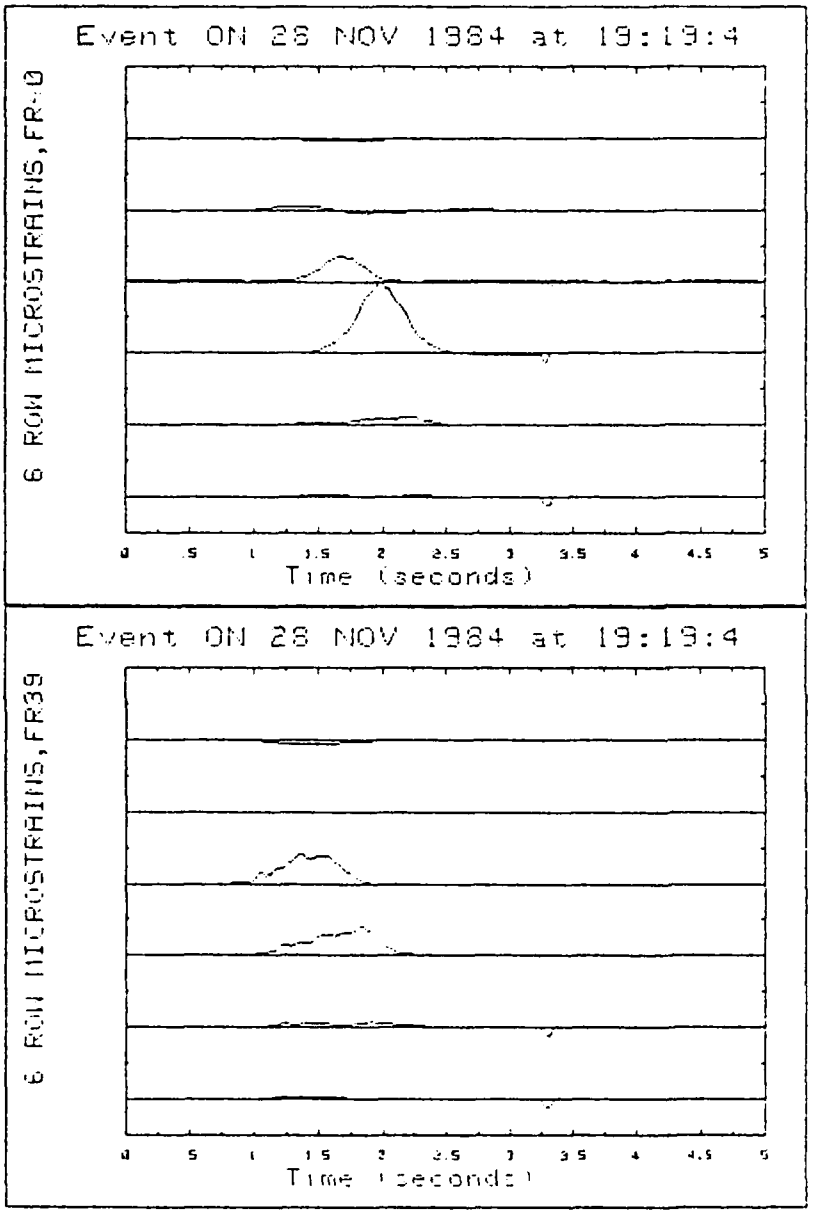
DATE	TIME	PM1	PA1	A1	F1	PM2	PA2	A2	F2	VEL
29 NOV 1984	20:39:54	509	46	36	174	415	44	38	175	2.3
28 NOV 1984	19:7:24	556	65	19	130	487	62	27	176	1.1
28 NOV 1984	19:19:4	1041	399	3	126	628	63	27	178	0.0
29 NOV 1984	22:16:32	503	60	25	157	342	74	23	179	3.3
28 NOV 1984	8:24:50	415	80	19	159	231	69	25	181	2.8
28 NOV 1984	8:46:35	560	105	15	165	398	82	21	181	0.0
29 NOV 1984	12:52:40	733	53	33	183	733	53	33	183	1.2
29 NOV 1984	14:35:42	796	293	4	123	554	145	12	183	3.5
28 NOV 1984	8:46:14	338	44	40	185	338	44	40	185	0.0
29 NOV 1984	16:5:37	338	56	29	170	314	57	31	185	1.6
29 NOV 1984	20:18:56	510	68	26	185	510	68	26	185	6.2
28 NOV 1984	8:51:22	379	42	42	185	199	43	42	189	0.0
1 DEC 1984	22:35:26	458	40	45	189	458	40	45	189	.2
28 NOV 1984	8:56:4	313	63	23	152	226	67	27	190	0.0
28 NOV 1984	7:54:32	335	54	18	102	174	52	35	191	1.9
28 NOV 1984	8:43:3	520	73	23	176	456	76	24	191	1.3
28 NOV 1984	18:9:41	478	53	22	122	246	63	29	192	2.8
28 NOV 1984	9:12:28	346	51	36	193	346	51	36	193	0.0
28 NOV 1984	19:20:56	487	65	15	102	236	68	27	193	0.0
29 NOV 1984	1:55:21	531	43	43	194	531	43	43	194	0.0
28 NOV 1984	8:54:48	479	179	7	131	445	87	22	201	0.0
29 NOV 1984	10:18:34	402	67	29	204	402	67	29	204	.1
28 NOV 1984	8:43:23	656	77	20	162	414	101	20	212	0.0
28 NOV 1984	18:26:46	775	170	12	214	775	170	12	214	.5
29 NOV 1984	20:35:31	659	59	24	149	639	69	30	217	1.0
29 NOV 1984	20:50:52	541	219	9	207	443	259	8	217	.2
18 NOV 1984	14:18:14	453	58	34	207	351	63	33	218	0.0
28 NOV 1984	9:16:2	427	73	24	184	355	99	21	219	0.0
28 NOV 1984	5:58:41	427	43	44	198	391	50	42	220	.2
1 DEC 1984	22:58:19	322	63	27	178	258	57	37	221	2.7
29 NOV 1984	22:16:27	719	56	41	241	699	59	39	241	4.9
28 NOV 1984	5:46:35	729	79	22	182	579	69	35	253	0.0
29 NOV 1984	10:12:37	666	137	10	144	275	58	43	262	.5
29 NOV 1984	22:58:23	729	56	46	270	729	56	46	270	3.0
28 NOV 1984	8:7:29	939	260	8	218	673	76	39	311	7.5
29 NOV 1984	19:28:2	785	785	1	82	717	184	19	367	0.0
29 NOV 1984	19:13:3	818	97	33	336	630	83	43	374	1.4

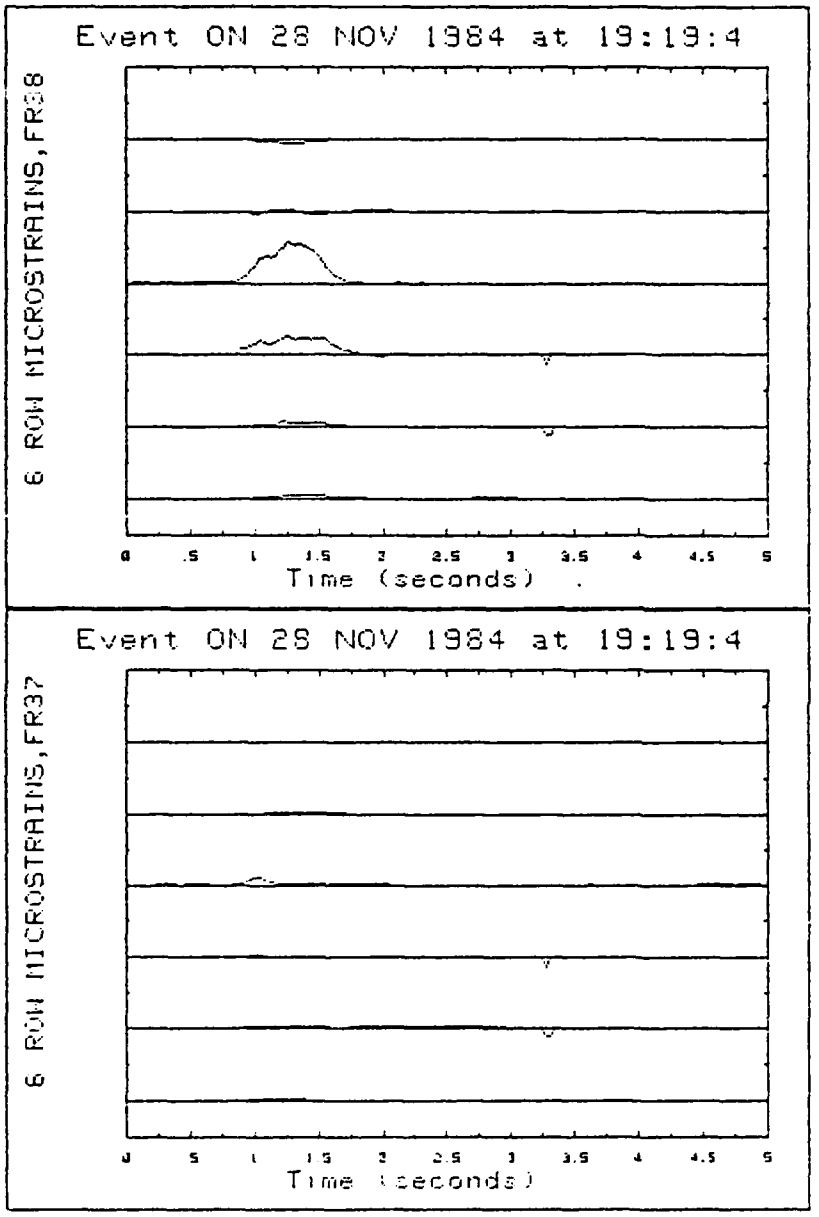
APPENDIX C

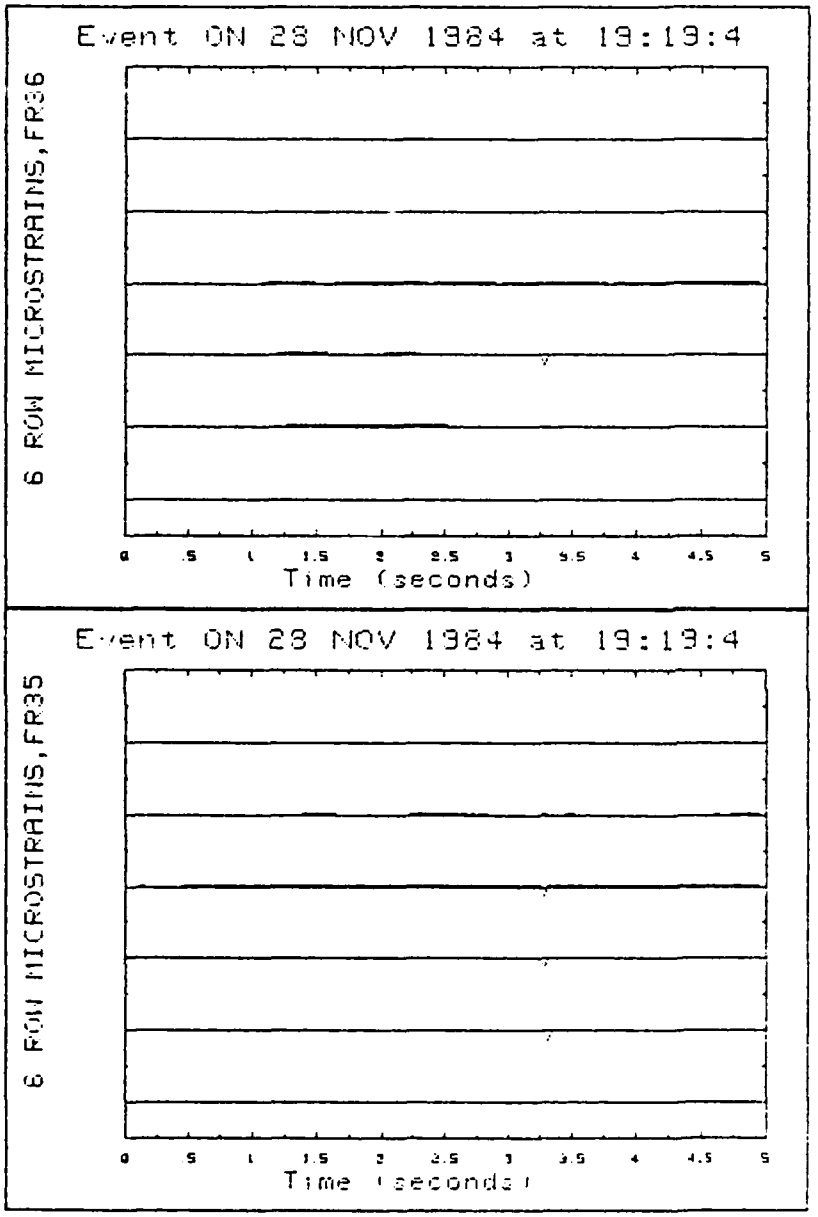
THE FIVE EVENTS OF HIGHEST SINGLE SUB-PANEL PRESSURE

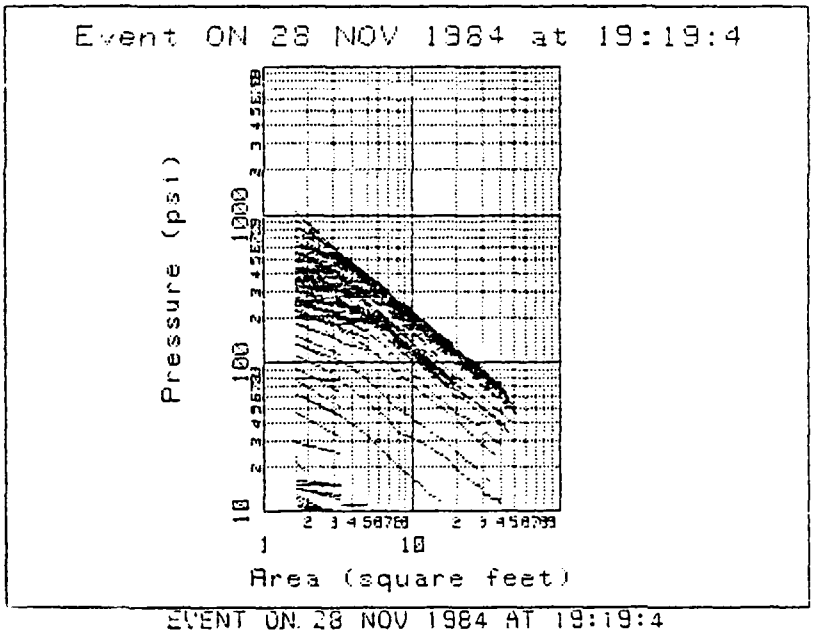



Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR42
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR-0
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR39
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR38
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS, FR36
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:19:4
6 ROW MICROSTRAINS, FR35
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)



EVENT ON 28 NOV 1984 AT 19:19:4
TAPE NUMBER 2 ; TRACK NUMBER 4 ; FILE NUMBER 42
PEAK STRAIN 553 ; THRESHOLD 175
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 1041 PSI; TIME FRAME 63; REAL TIME 1.97
FRAME 40; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90
Pressure	1041.00	572.00	399.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50
PRESSURE	1041.00	78.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67
PRESSURE	1041.00	572.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 178 LONG TONS: TIME FRAME 43; REAL TIME 1.34
FRAME 38: ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

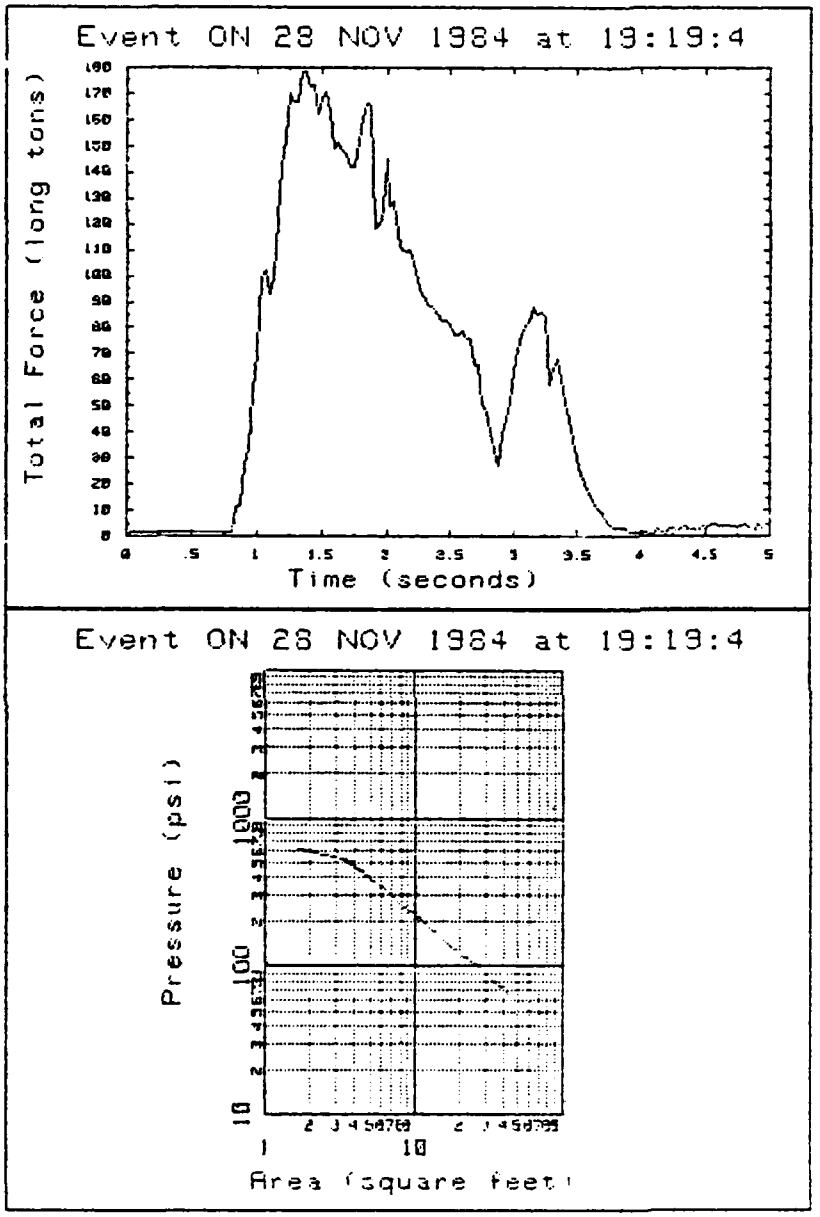
Area	1.63	3.25	4.90	6.53	8.16	9.79	11.42
Pressure	629.00	538.00	398.00	318.00	261.00	231.00	200.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	178.00	160.00	145.00	132.00	125.00	116.00	111.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	104.00	100.00	95.00	90.00	86.00	82.00	76.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	
Pressure	75.00	73.00	70.00	67.00	66.00	63.00	

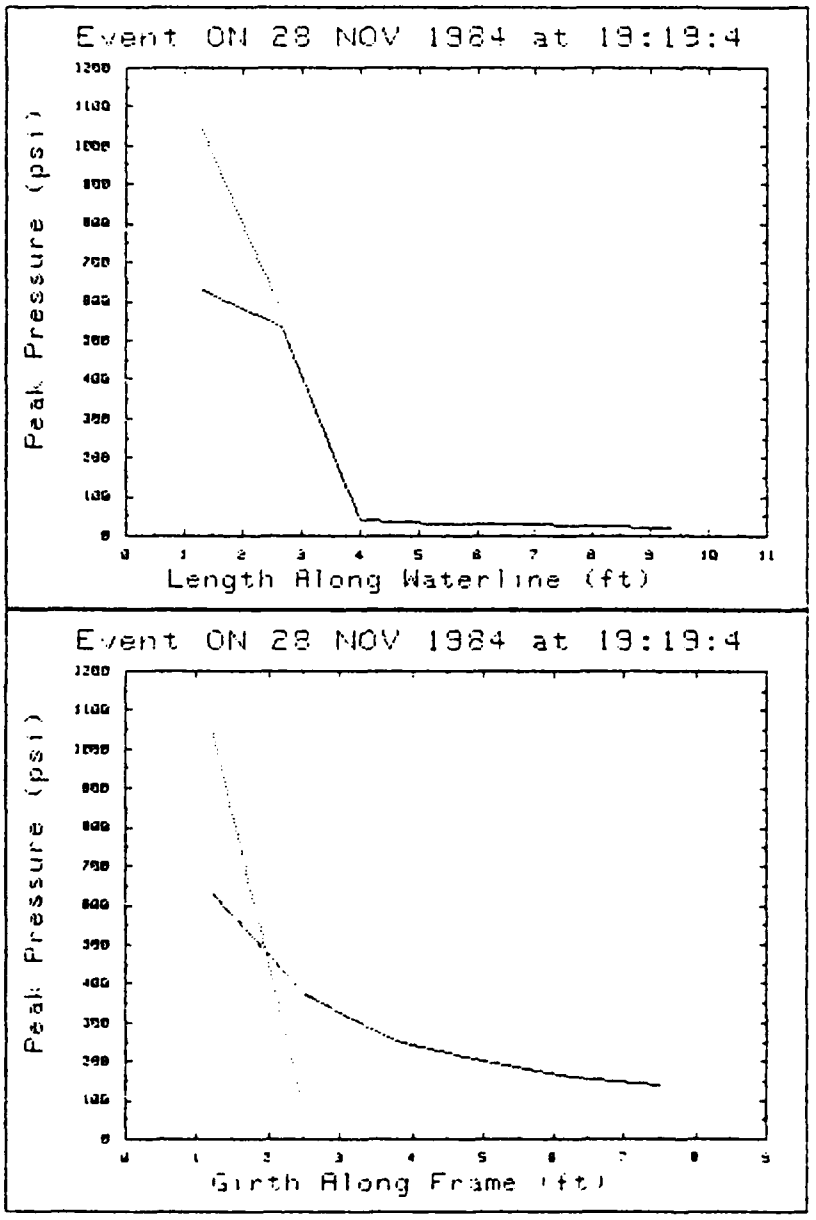
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

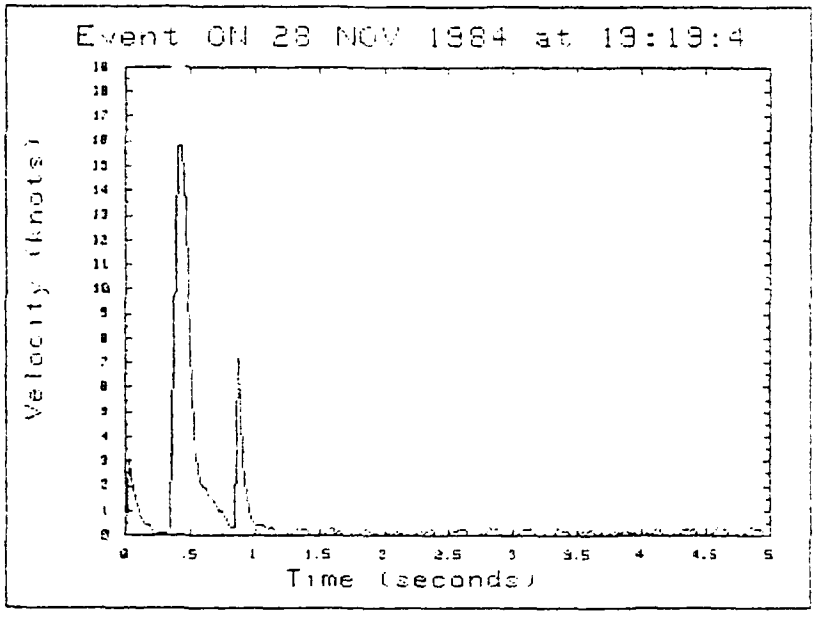
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	628.00	376.00	252.00	200.00	160.00	139.00

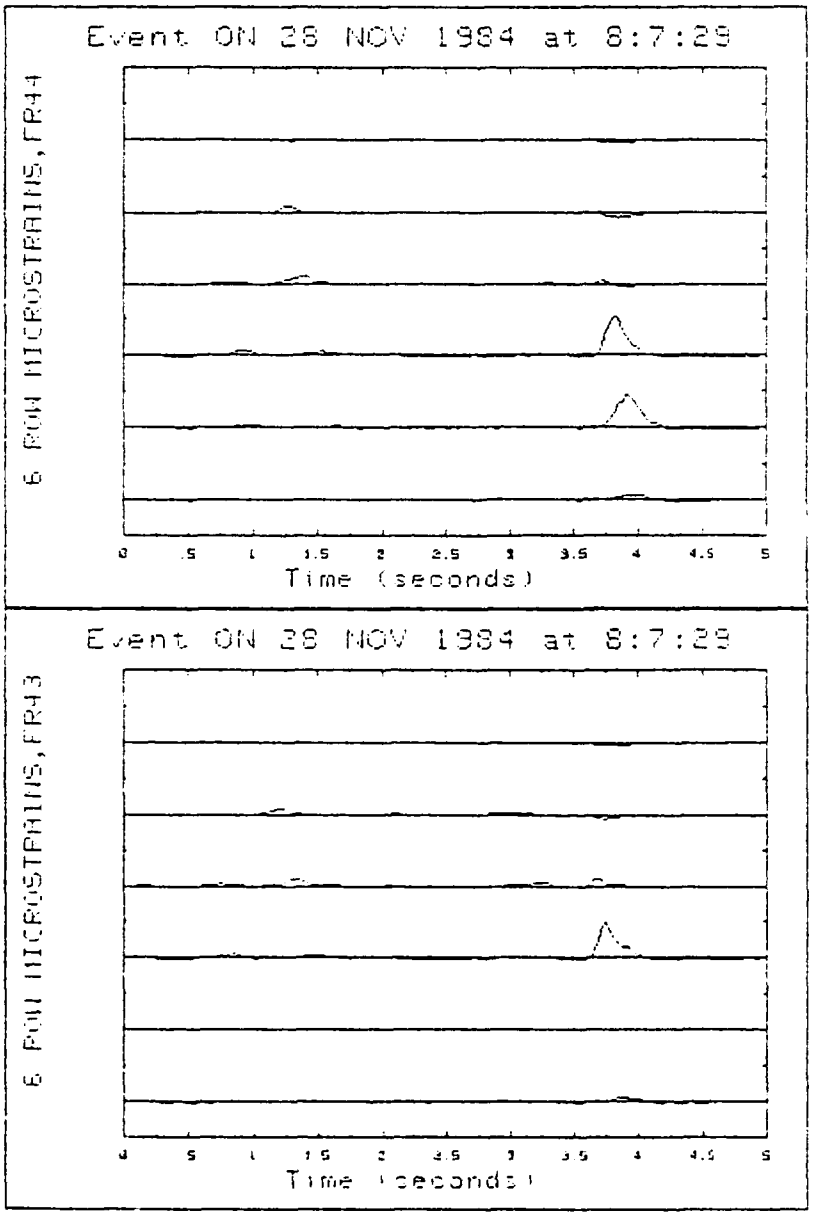
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

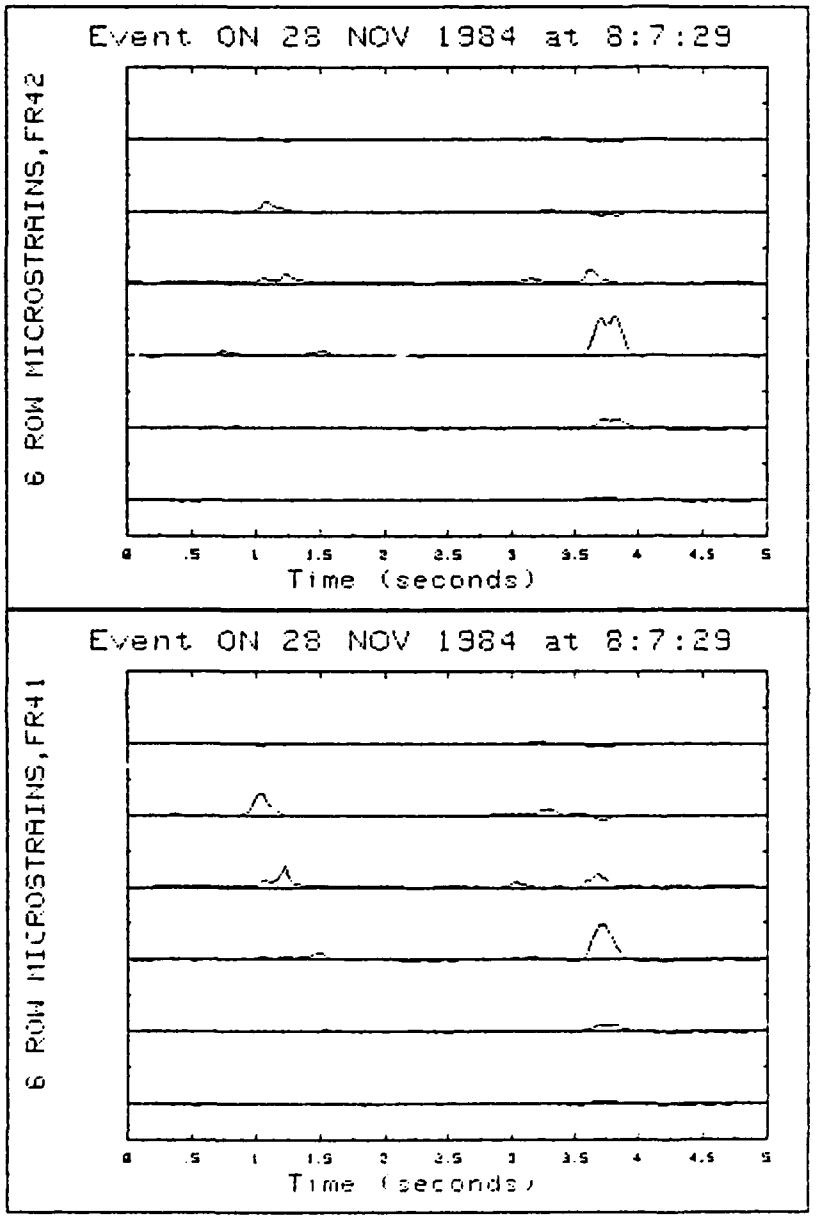
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	628.00	538.00	41.00	34.00	29.00	25.00	22.00

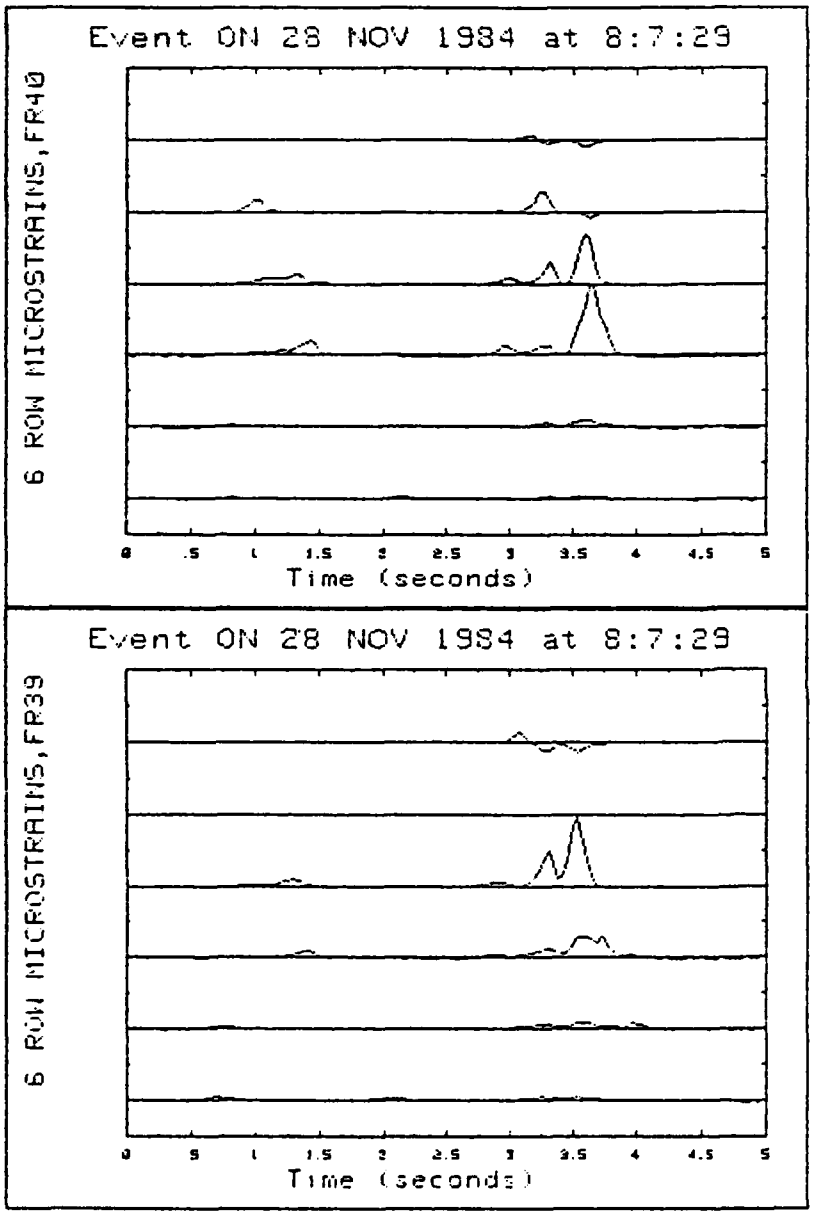

Event ON 28 NOV 1984 at 19:19:4
Total Force (long tons)
Time (seconds)
Event ON 28 NOV 1984 at 19:19:4
Pressure (psi)
Area (square feet)

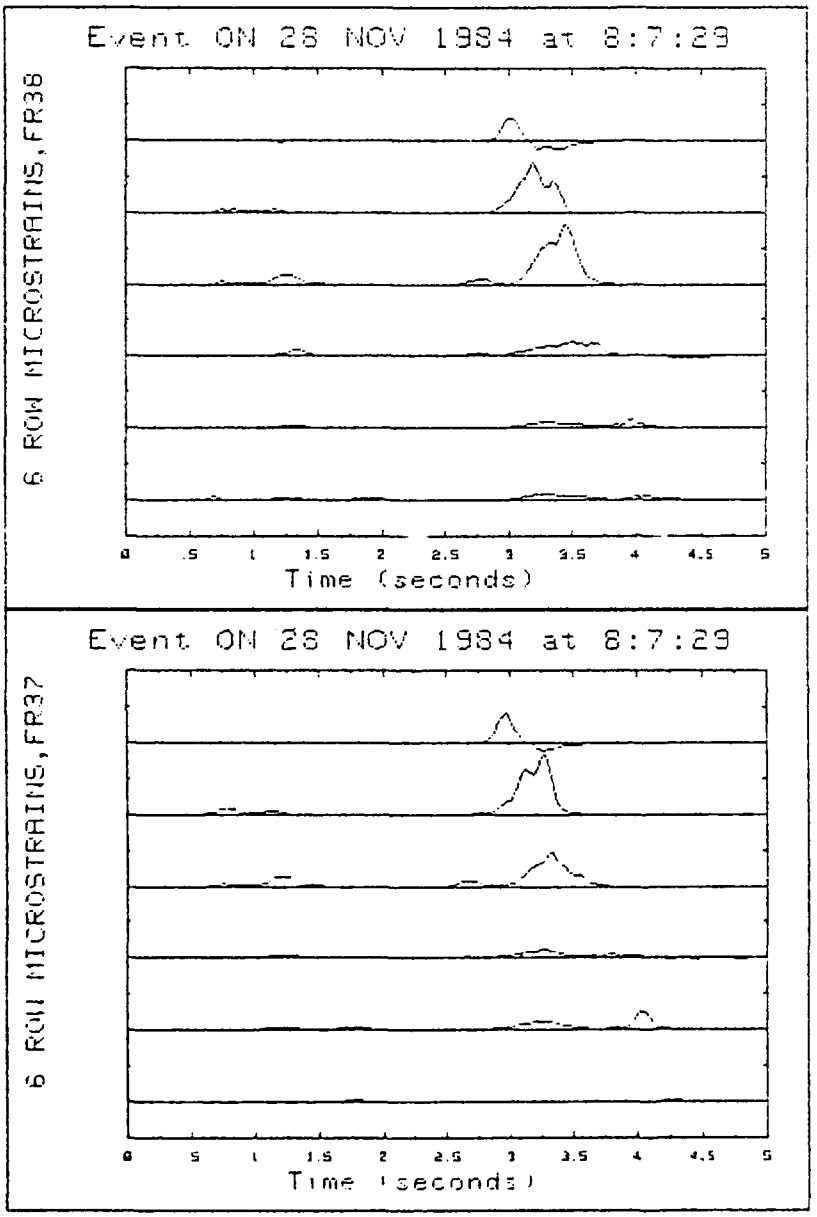

Event ON 28 NOV 1984 at 19:19:4
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 28 NOV 1984 at 19:19:4
Peak Pressure (psi)
Girth Along Frame (ft)

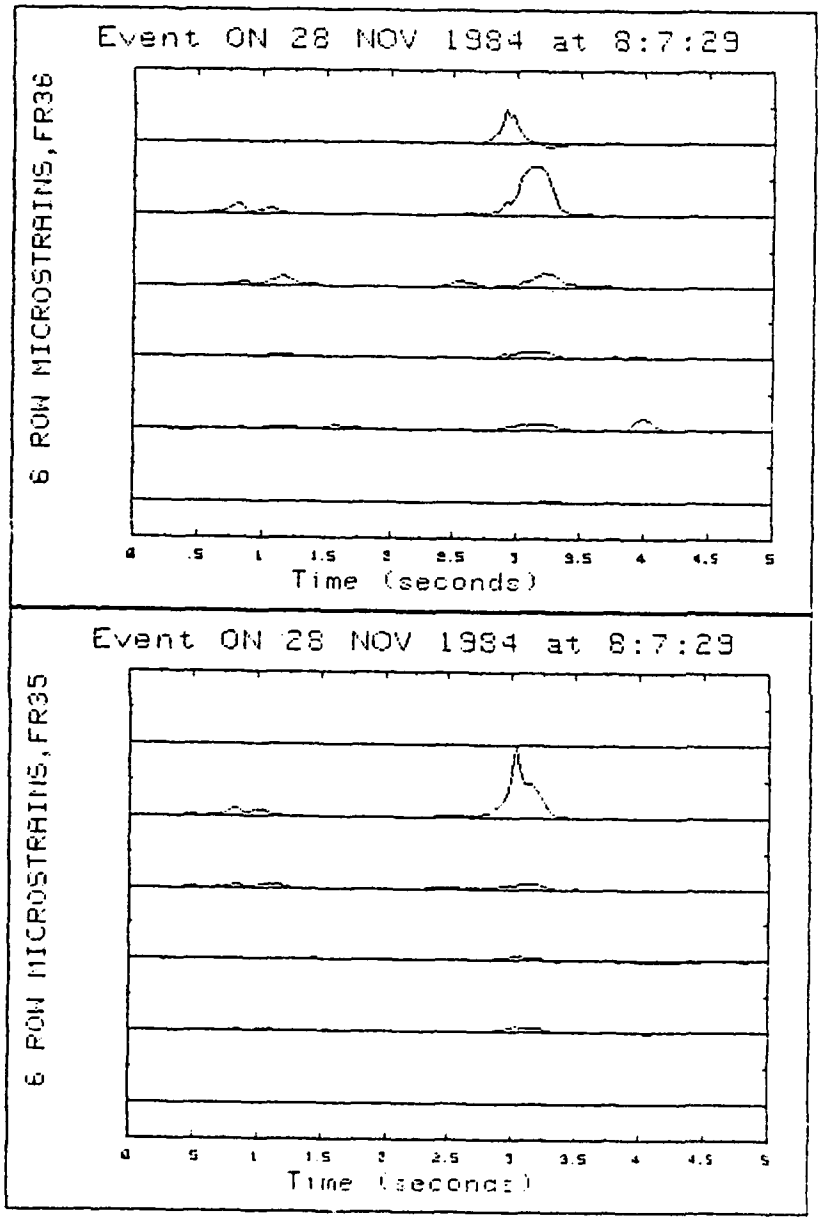

Event ON 28 NOV 1984 at 19:19:4
Velocity (knots)
Time (seconds)
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

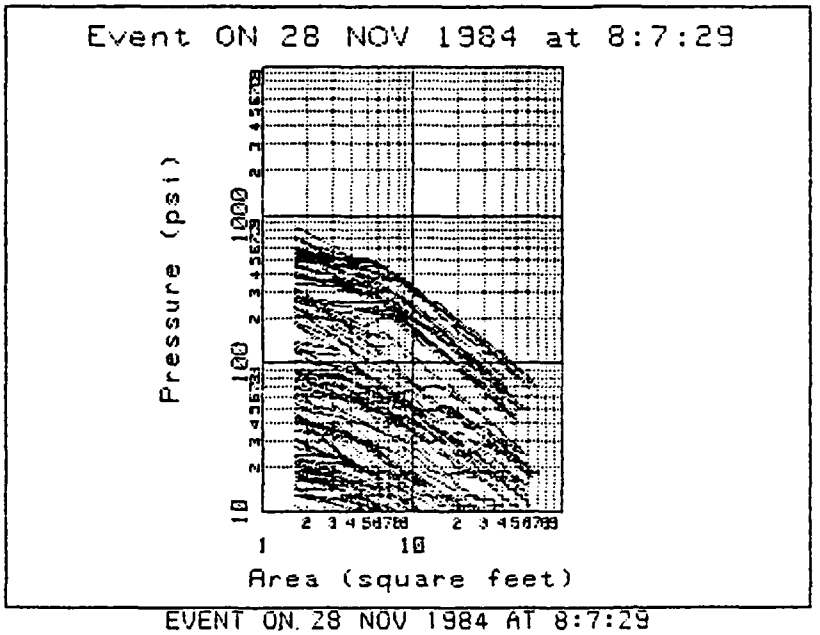

Event ON 28 NOV 1984 at 8:7:29
6 POW MICROSTRAINS,FR44
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 8:7:29
6 POW MICROSTRAINS,FR43
Time (seconds)


Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR42
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR41
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR40
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR39
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR36
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS,FR37
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS, FR36
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 28 NOV 1984 at 8:7:29
6 ROW MICROSTRAINS, FR35
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)



EVENT ON 28 NOV 1984 AT 8:7:29
TAPE NUMBER 2 ; TRACK NUMBER 3 ; FILE NUMBER 27
PEAK STRAIN 329 ; THRESHOLD 100
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 838 PSI; TIME FRAME 97; REAL TIME 3.03
FRAME 35; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	838.00	586.00	444.00	375.00	356.00	318.00	288.00

Area	13.06
Pressure	260.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50
PRESSURE	838.00	230.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33
PRESSURE	838.00	586.00	444.00	361.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 311 LONG TONS; TIME FRAME 104; REAL TIME 3.25
FRAME 37; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

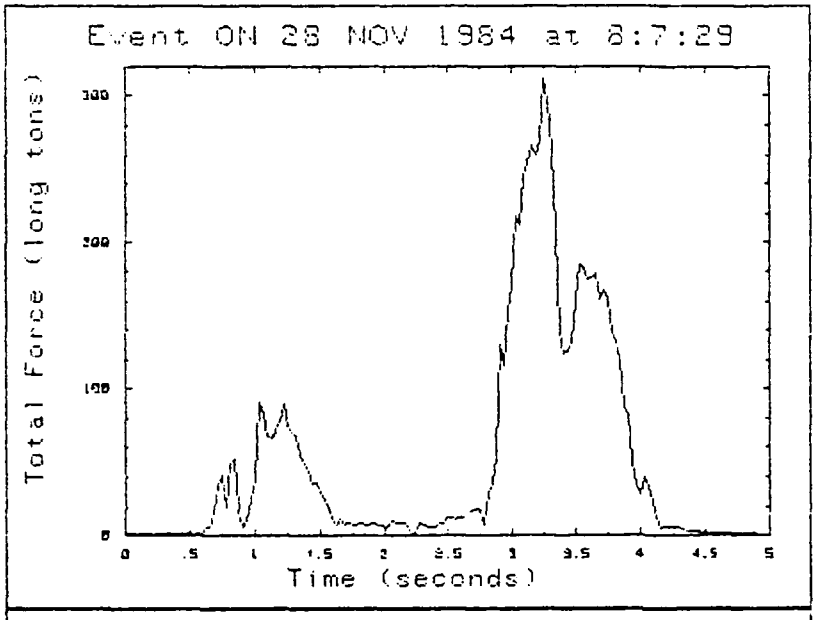
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	673.00	542.00	491.00	430.00	385.00	344.00	303.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	269.00	241.00	224.00	207.00	192.00	179.00	168.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	158.00	151.00	144.00	137.00	132.00	126.00	120.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	115.00	122.00	118.00	114.00	110.00	106.00	103.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	99.00	96.00	93.00	91.00	88.00	87.00	84.00
Area	58.75	60.38	62.01	63.65			
Pressure	82.00	80.00	78.00	76.00			

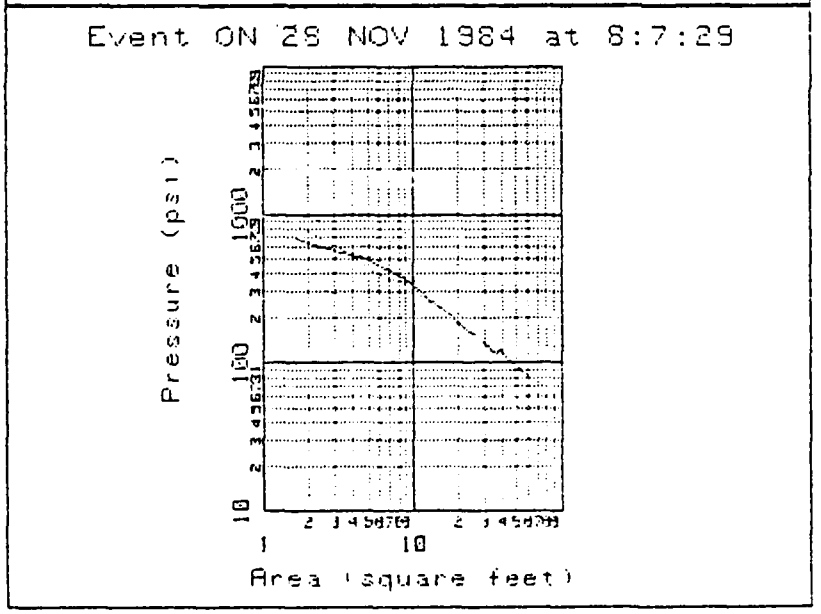
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

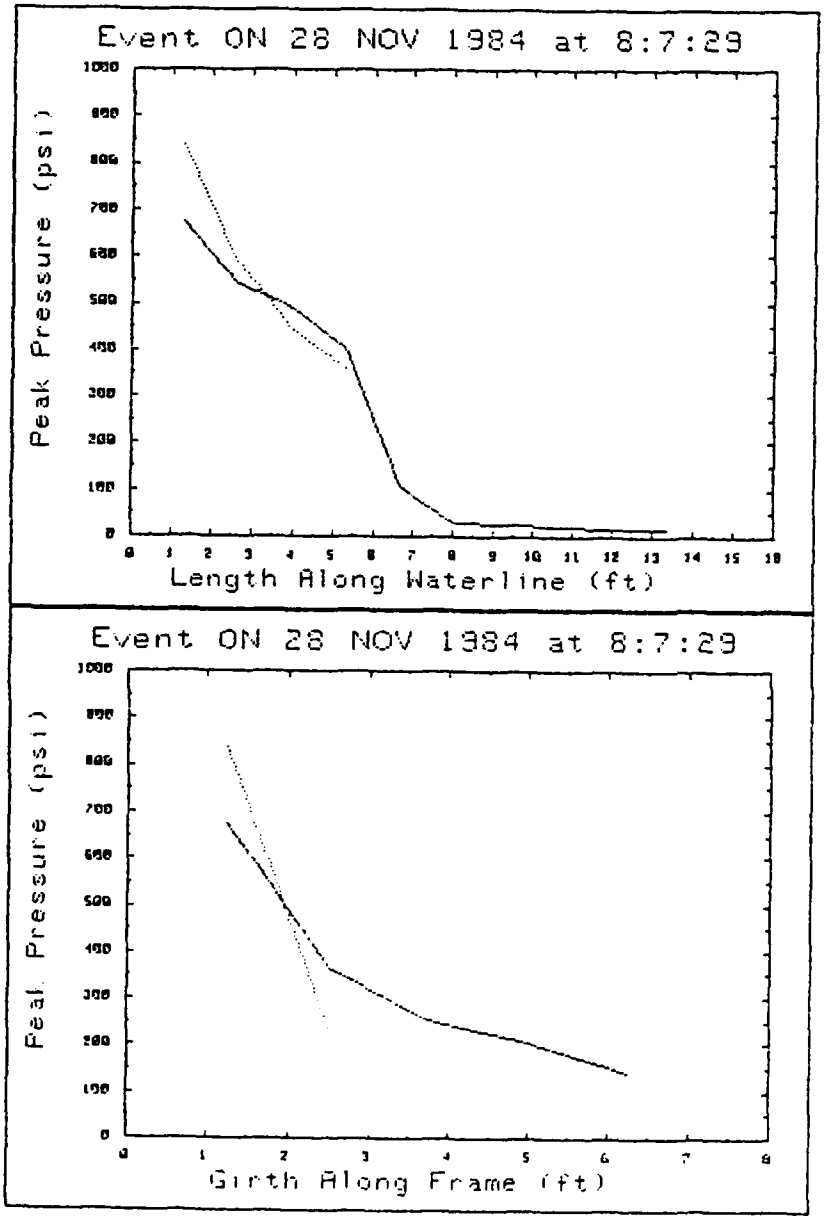
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	673.00	367.00	252.00	206.00	144.00

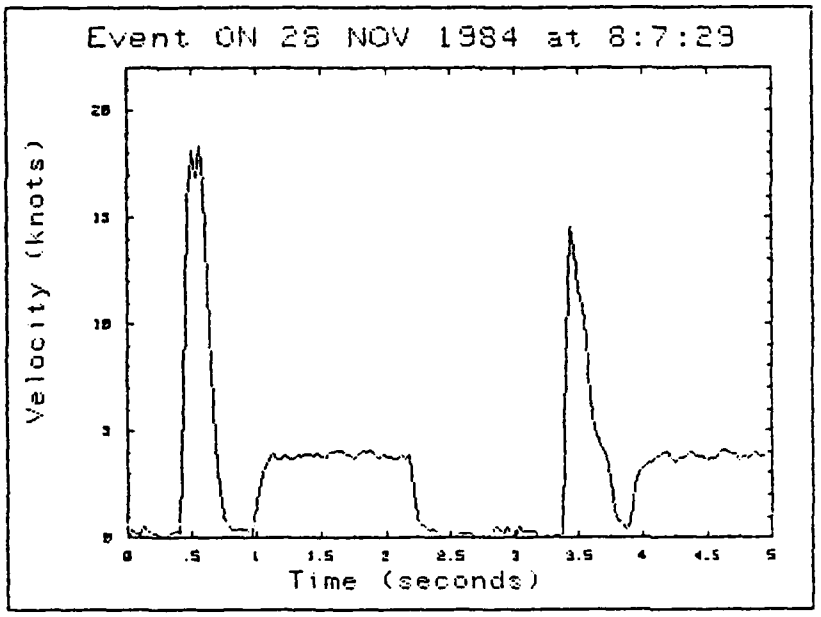
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

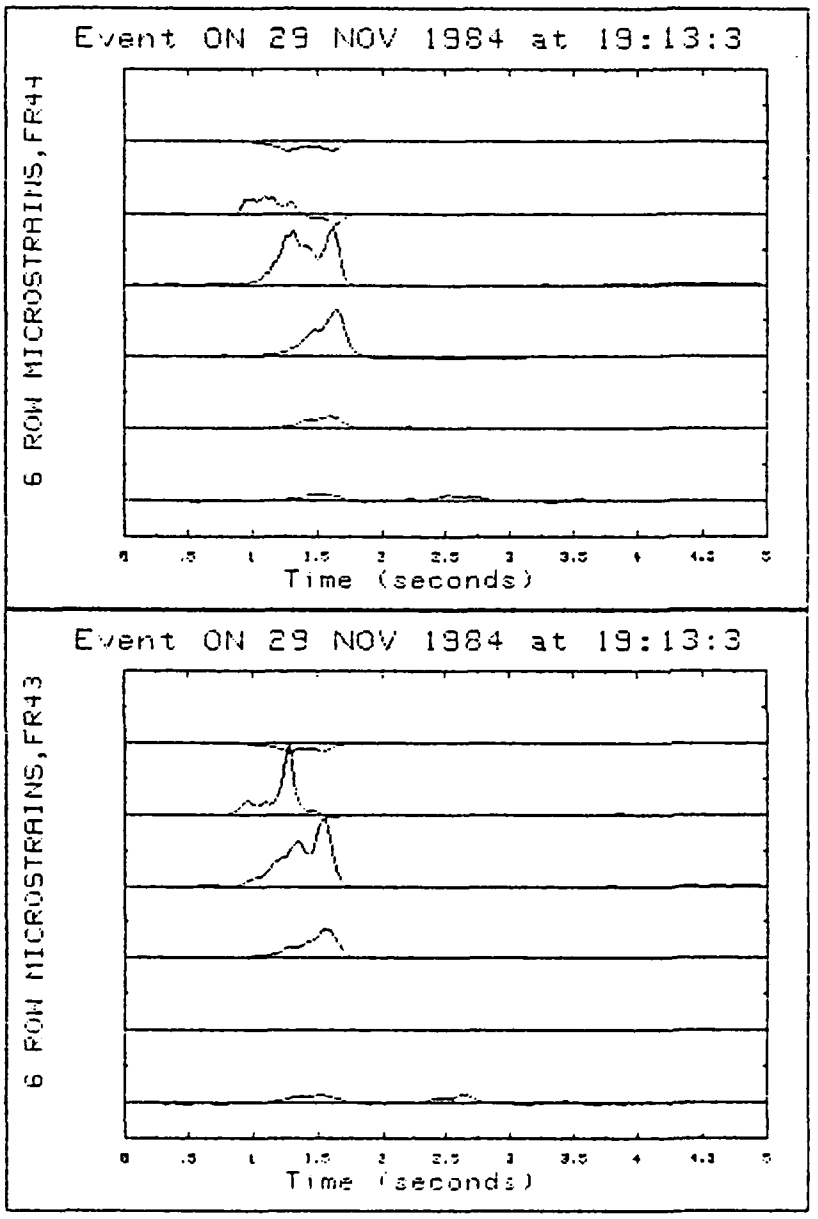
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	673.00	542.00	491.00	404.00	107.00	29.00	26.00
LENGTH	10.67	12.00	13.33				
PRESSURE	21.00	19.00	17.00				

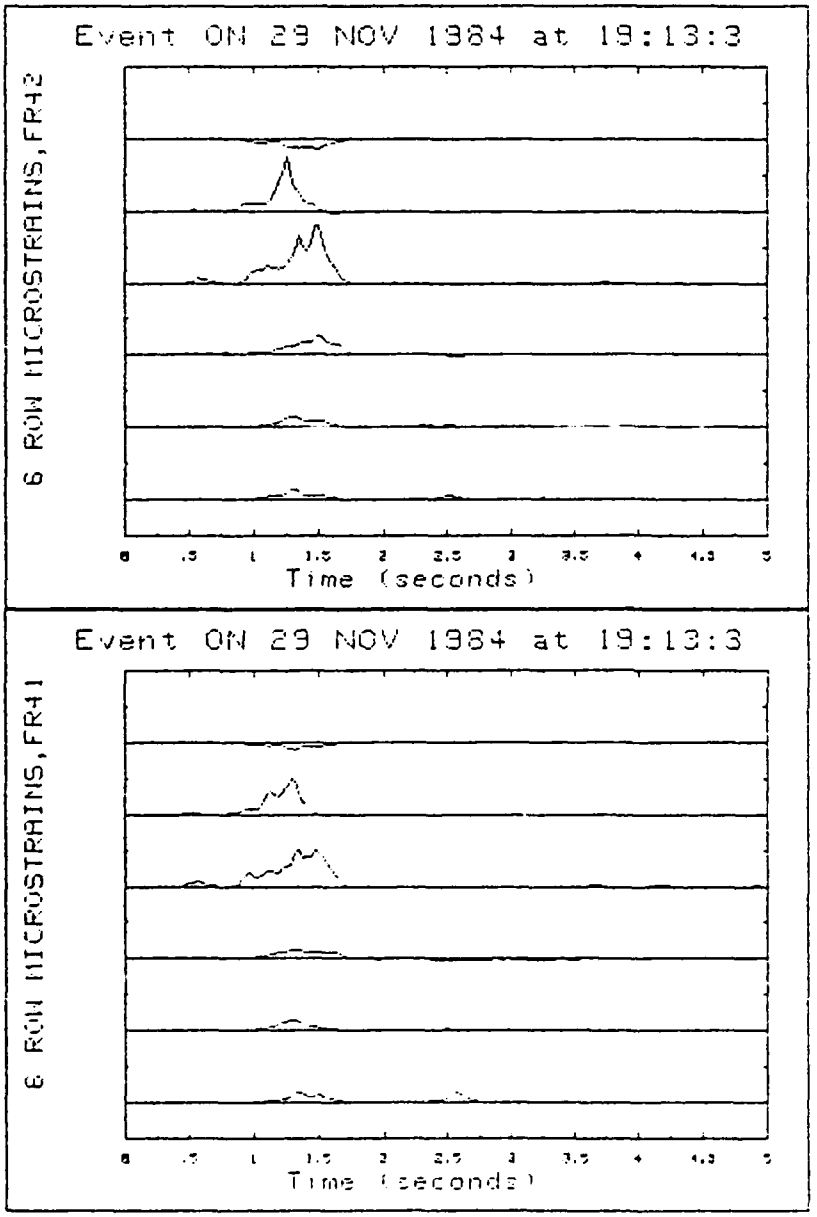

Event ON 28 NOV 1984 at 8:7:29
Total Force (long tons)
300
200
100
0
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)

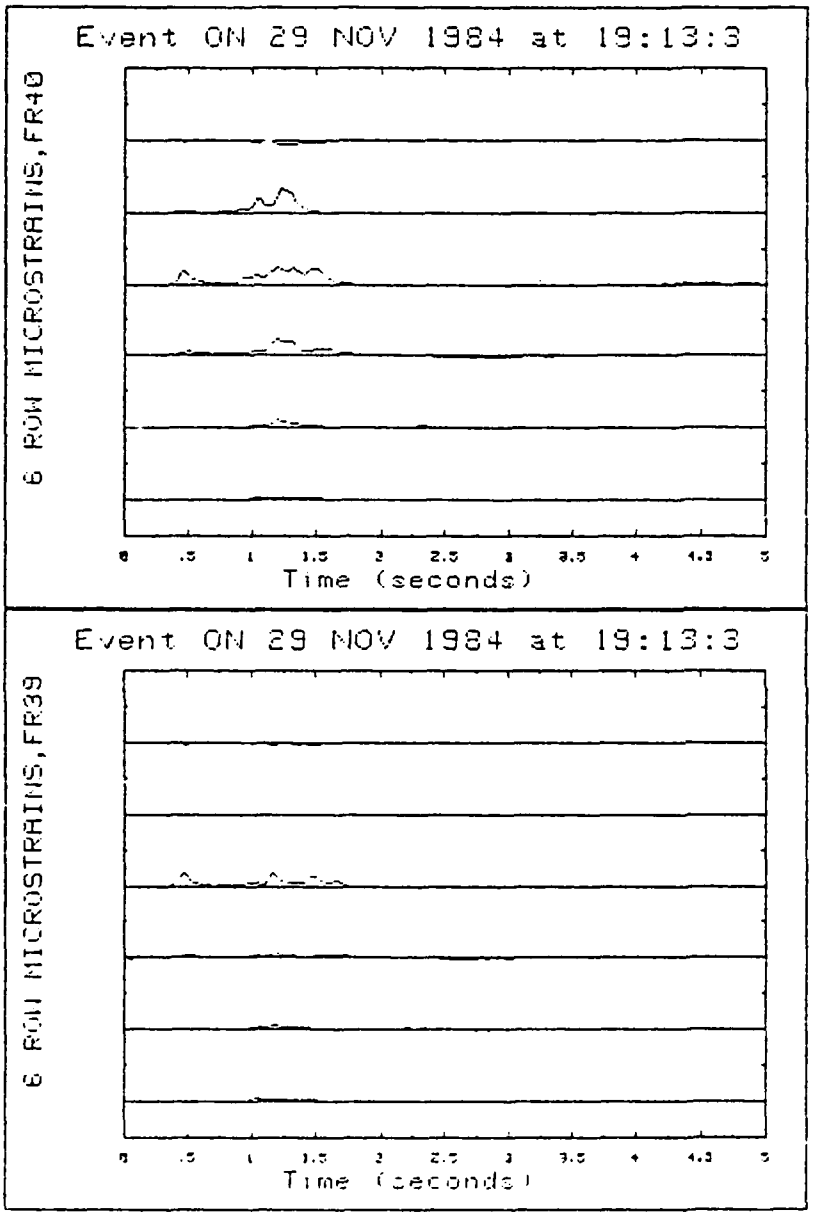

Event ON 28 NOV 1984 at 8:7:29
Pressure (psi)
1000
100
10
1
10
Area (square feet)

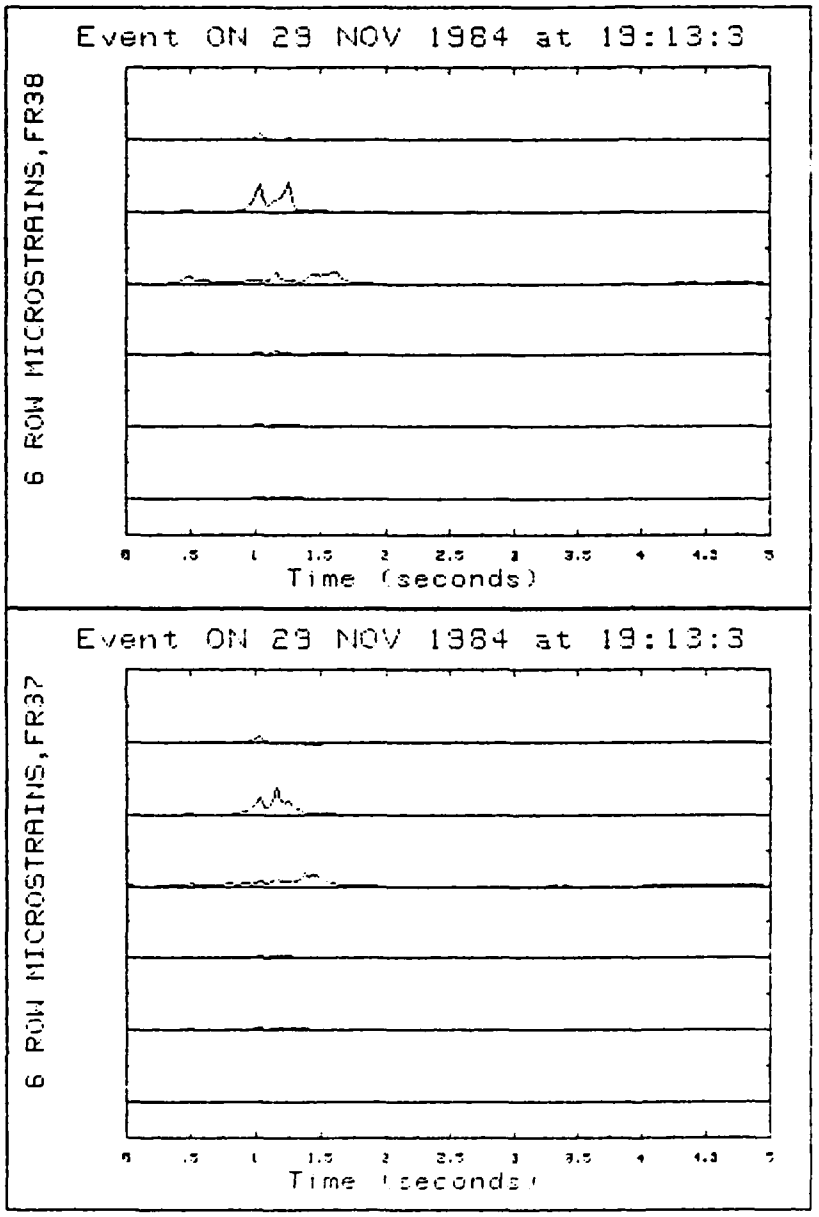

Event ON 28 NOV 1984 at 8:7:29
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 28 NOV 1984 at 8:7:29
Peak Pressure (psi)
Girth Along Frame (ft)

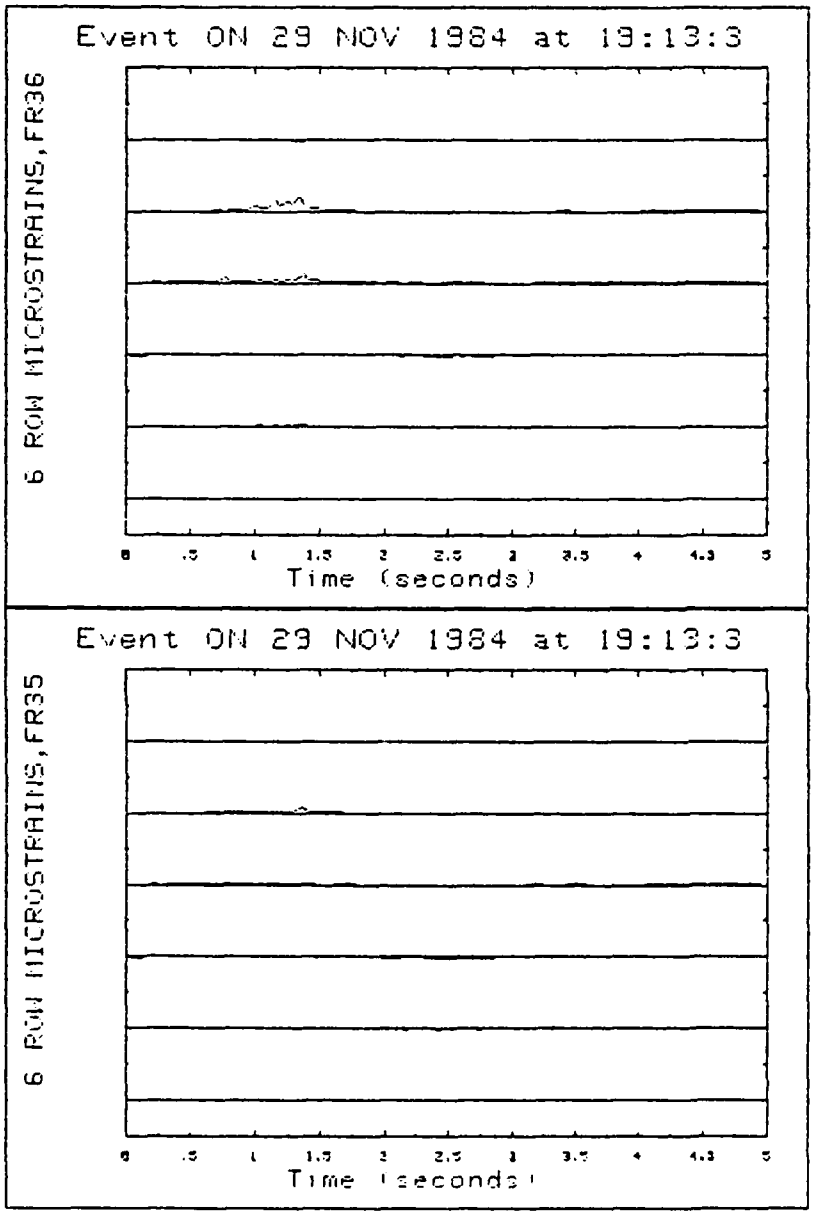

Event ON 28 NOV 1984 at 8:7:29
Velocity (knots)
Time (seconds)
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

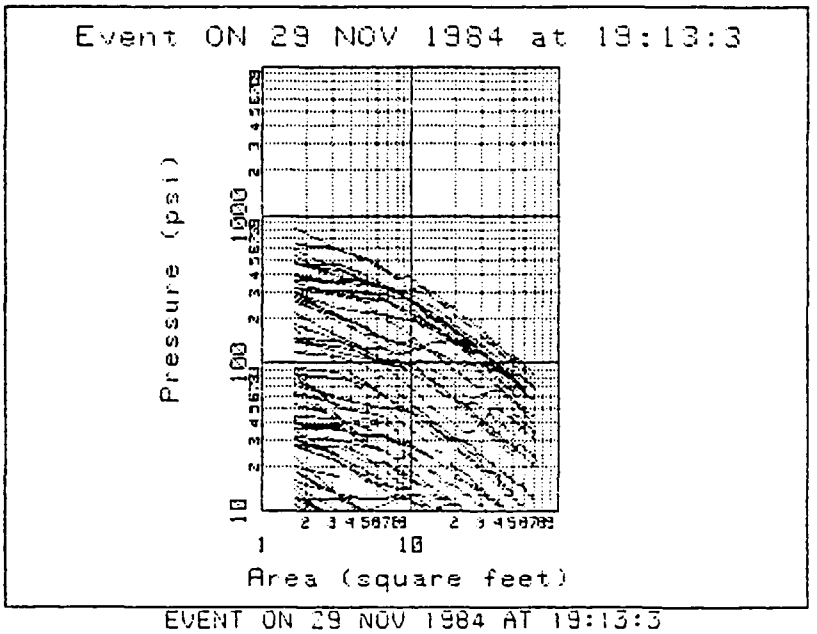

Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS, FR44
Time (seconds)
Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS, FR43
Time (seconds)


Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 29 NOV 1984 at 19:13:3
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 29 NOV 1984 AT 19:13:3
TAPE NUMBER 3 ; TRACK NUMBER 1 ; FILE NUMBER 29
PEAK STRAIN 302 ; THRESHOLD 125
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 818 PSI; TIME FRAME 41; REAL TIME 1.28
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	818.00	589.00	515.00	439.00	373.00	386.00	346.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	316.00	289.00	266.00	246.00	233.00	218.00	205.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	196.00	187.00	178.00	170.00	162.00	155.00	148.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	142.00	136.00	131.00	126.00	121.00	117.00	113.00
Area	47.33	48.96	50.59	52.22	53.85		
Pressure	110.00	106.00	103.00	100.00	97.00		

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	818.00	464.00	327.00	136.00	121.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	818.00	589.00	515.00	439.00	367.00	141.00	21.00

LENGTH	10.67
PRESSURE	19.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 374 LONG TONS; TIME FRAME 40; REAL TIME 1.25
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	630.00	598.00	480.00	422.00	360.00	313.00	335.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	300.00	270.00	248.00	230.00	213.00	199.00	192.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	181.00	172.00	163.00	156.00	148.00	142.00	136.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	130.00	125.00	121.00	116.00	113.00	109.00	105.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	102.00	102.00	110.00	109.00	107.00	104.00	102.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	99.00	96.00	94.00	92.00	89.00	87.00	85.00
Area	70.17						
Pressure	83.00						

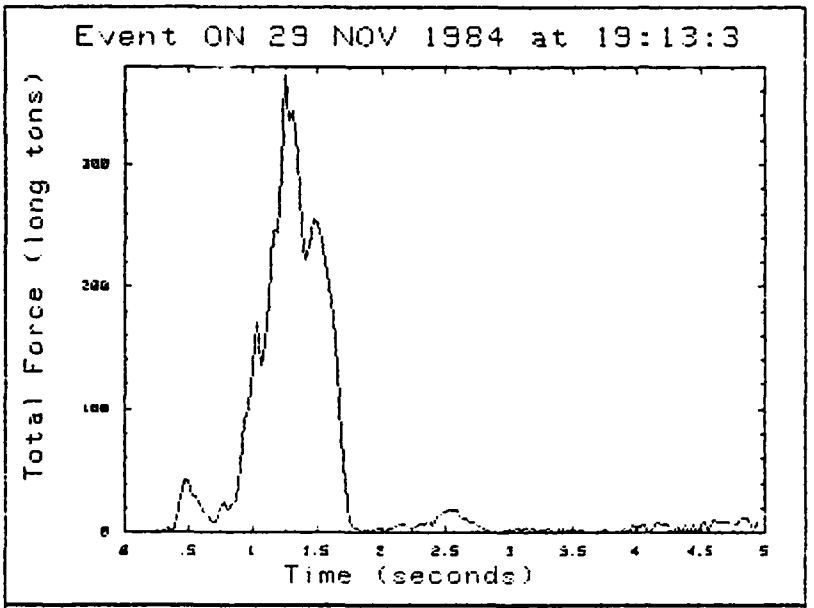
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

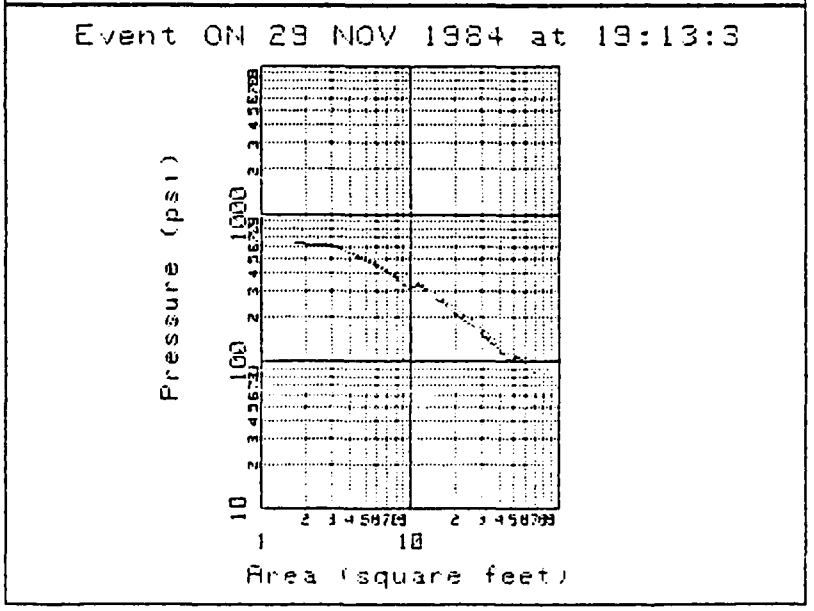
GIRTH	1.25	2.50	3.75	5.00	6.25
PRESSURE	630.00	354.00	253.00	169.00	142.00

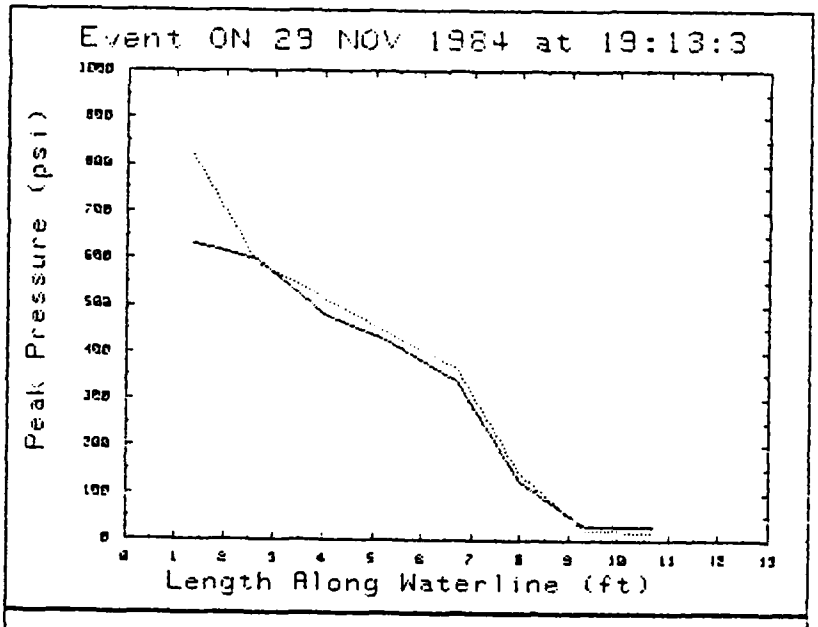
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

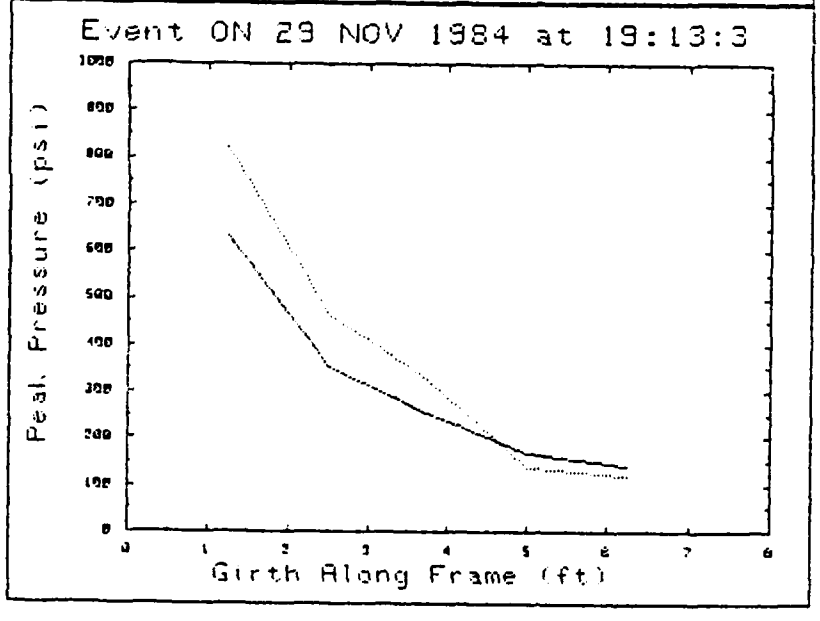
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	630.00	598.00	480.00	422.00	340.00	126.00	32.00

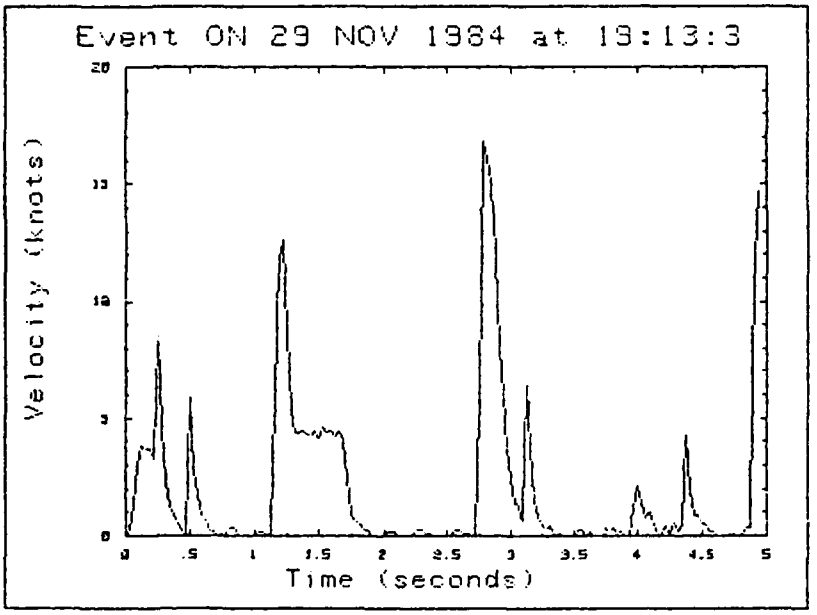
LENGTH	10.67
PRESSURE	29.00

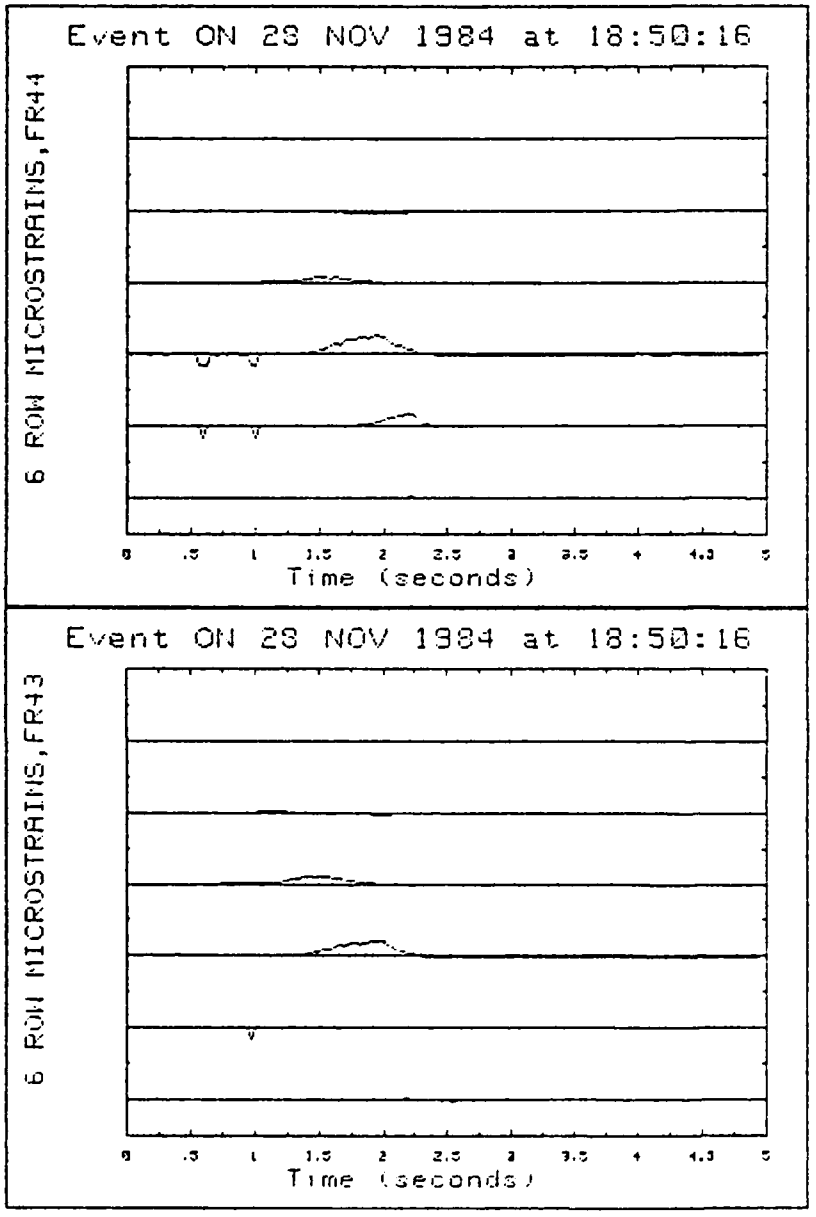

Event ON 29 NOV 1984 at 19:13:3
Total Force (long tons)
Time (seconds)

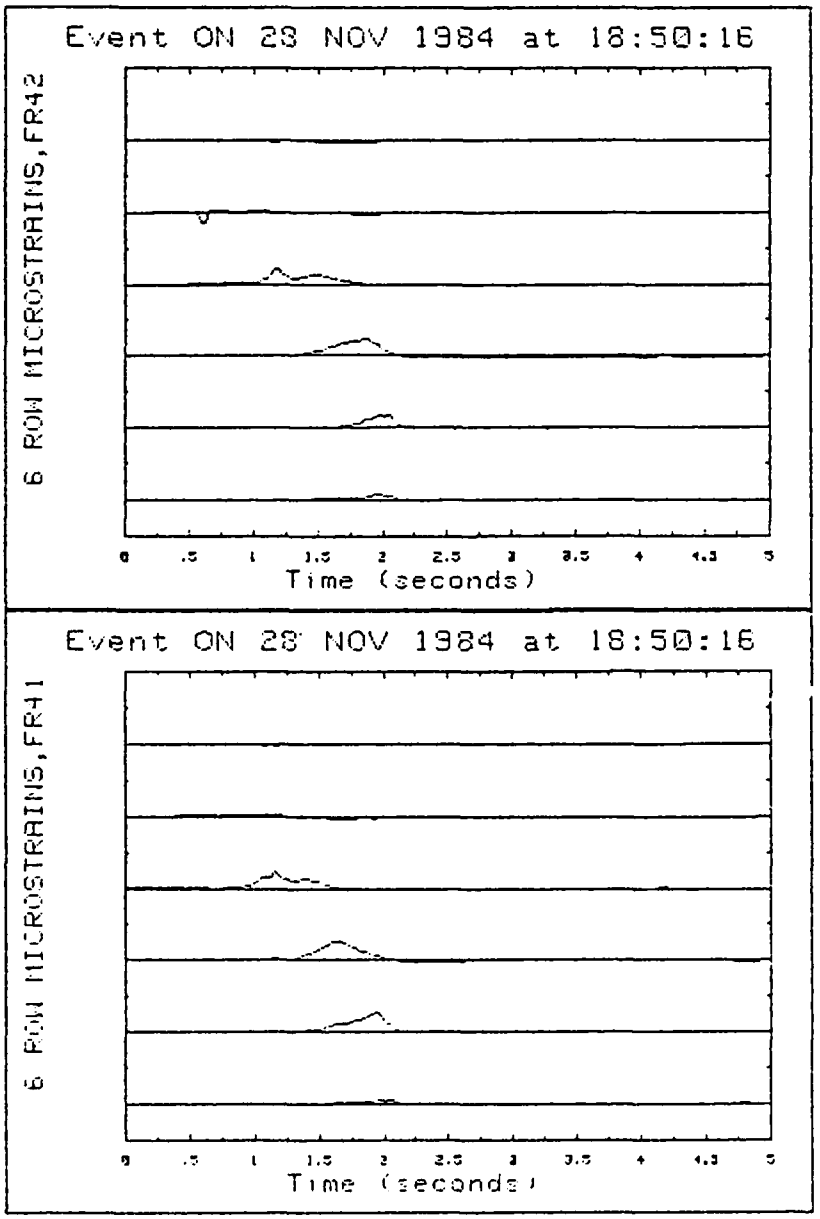

Event ON 29 NOV 1984 at 19:13:3
Pressure (psi)
Area (square feet)

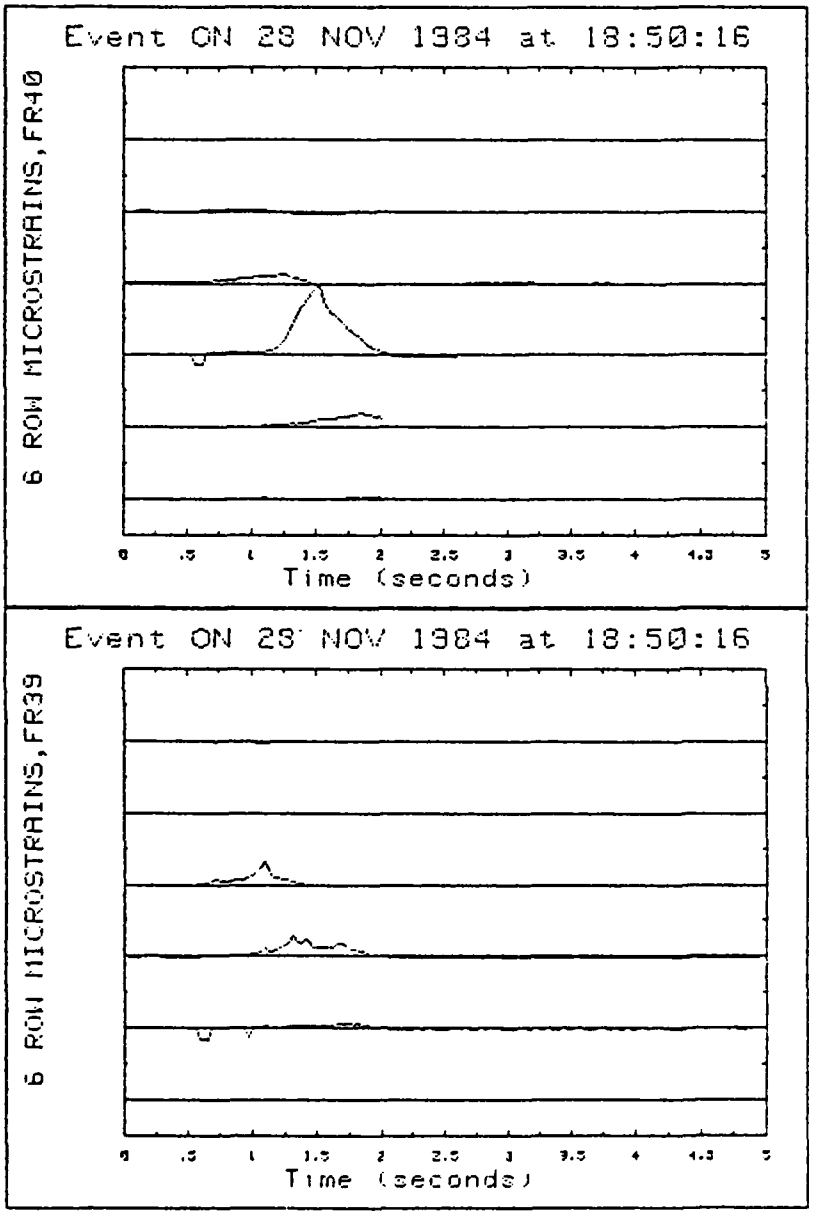

Event ON 29 NOV 1984 at 19:13:3
Peak Pressure (psi)
Length Along Waterline (ft)

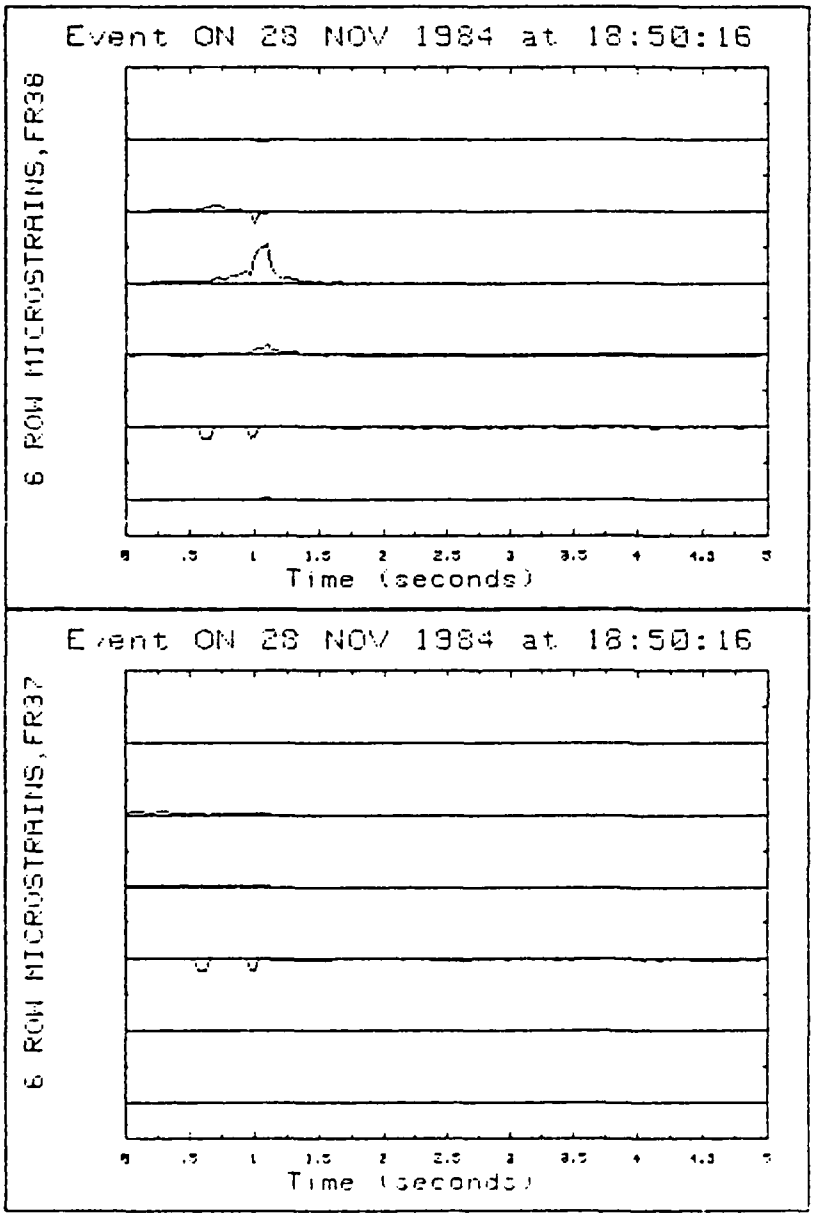

Event ON 29 NOV 1984 at 19:13:3
Peak Pressure (psi)
Girth Along Frame (ft)

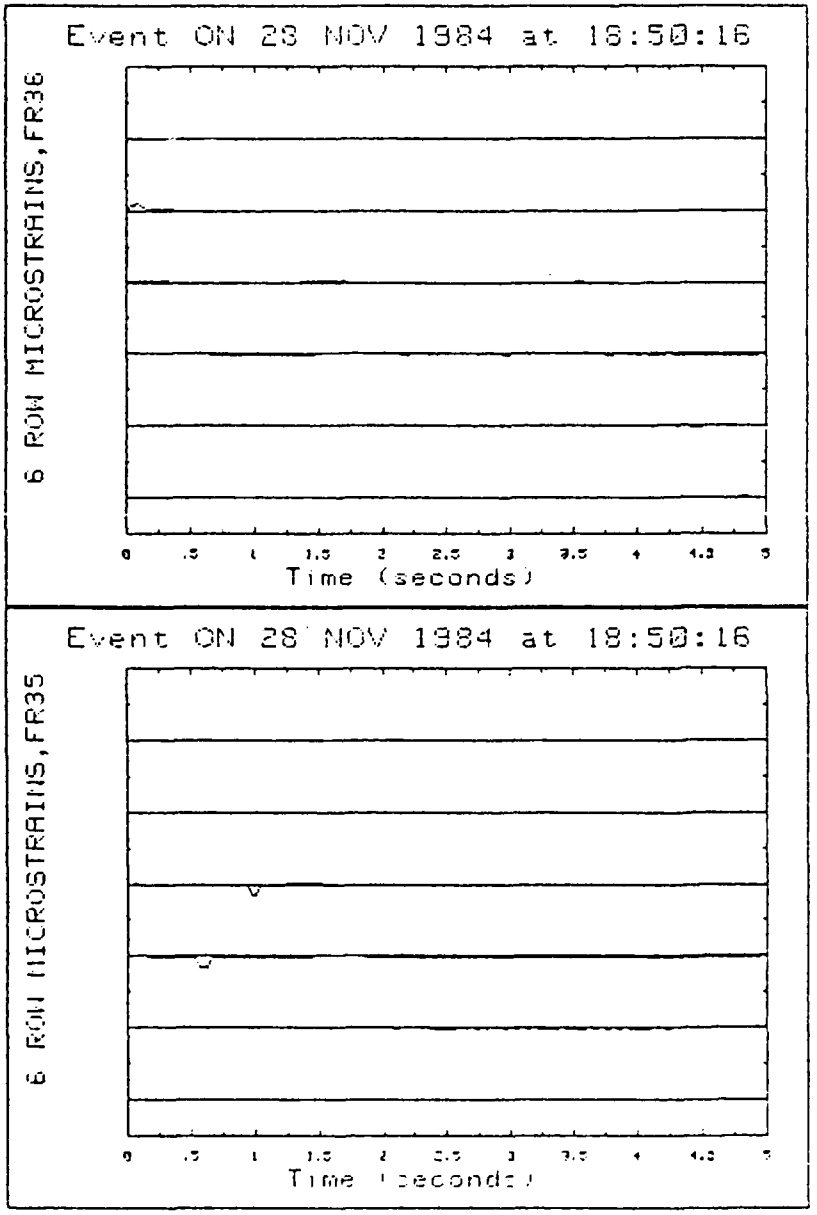

Event ON 29 NOV 1984 at 18:13:3
Velocity (knots)
Time (seconds)
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

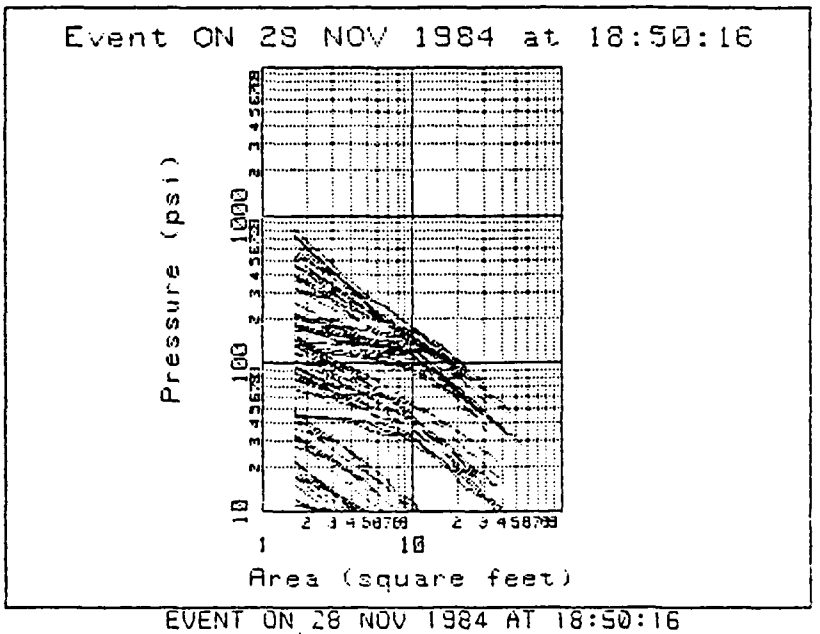

Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS, FR44
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS, FR43
Time (seconds)


Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS, FR36
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS, FR37
Time (seconds)


Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 28 NOV 1984 AT 18:50:16
TAPE NUMBER 2 ; TRACK NUMBER 4 ; FILE NUMBER 36
PEAK STRAIN 426 ; THRESHOLD 175
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 811 PSI; TIME FRAME 49; REAL TIME 1.53
FRAME 40; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	811.00	424.00	295.00	242.00	209.00	183.00	164.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	149.00	137.00	126.00	116.00	109.00	101.00	95.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75
PRESSURE	811.00	65.00	38.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00
PRESSURE	811.00	424.00	292.00	232.00	195.00	166.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 140 LONG TONS; TIME FRAME 48; REAL TIME 1.50
FRAME 40; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

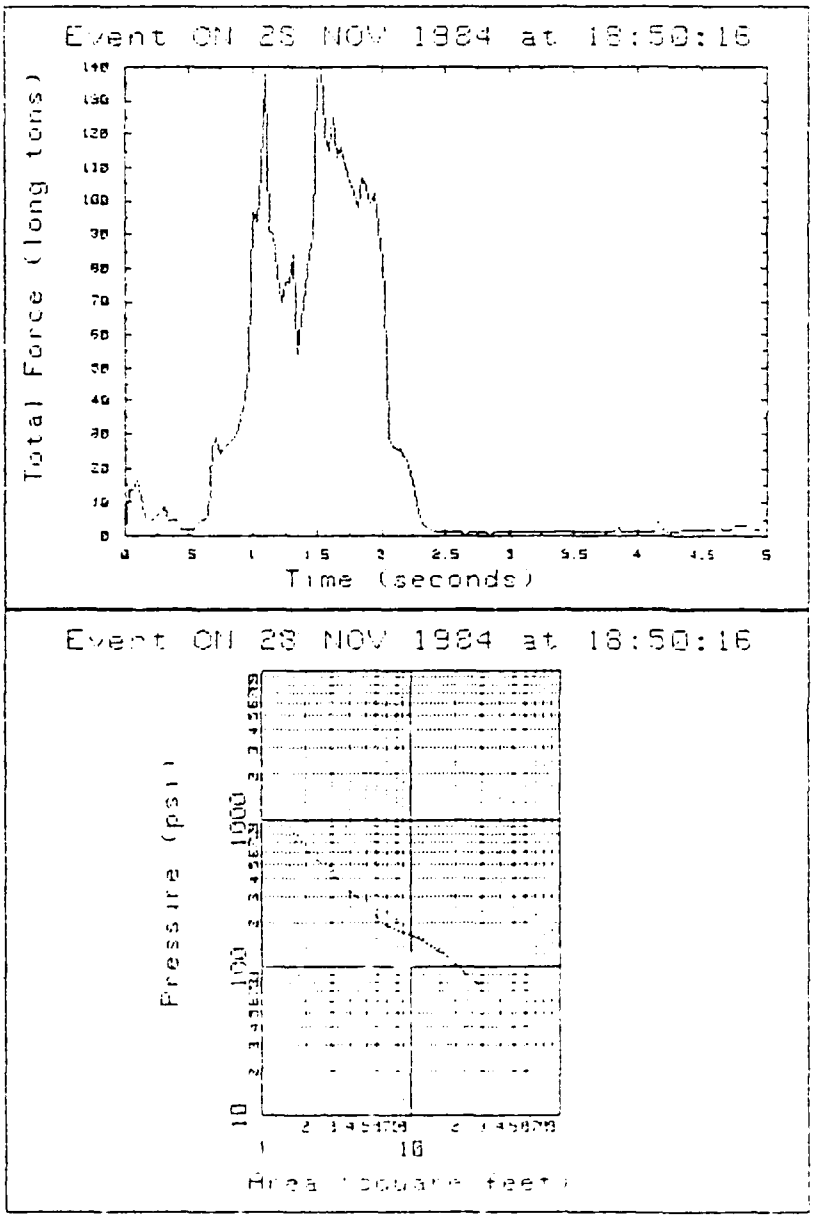
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	749.00	388.00	265.00	204.00	179.00	166.00	155.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	142.00	130.00	121.00	113.00	106.00	98.00	92.00
Area	24.48	26.11	27.74	29.38			
Pressure	86.00	82.00	78.00	74.00			

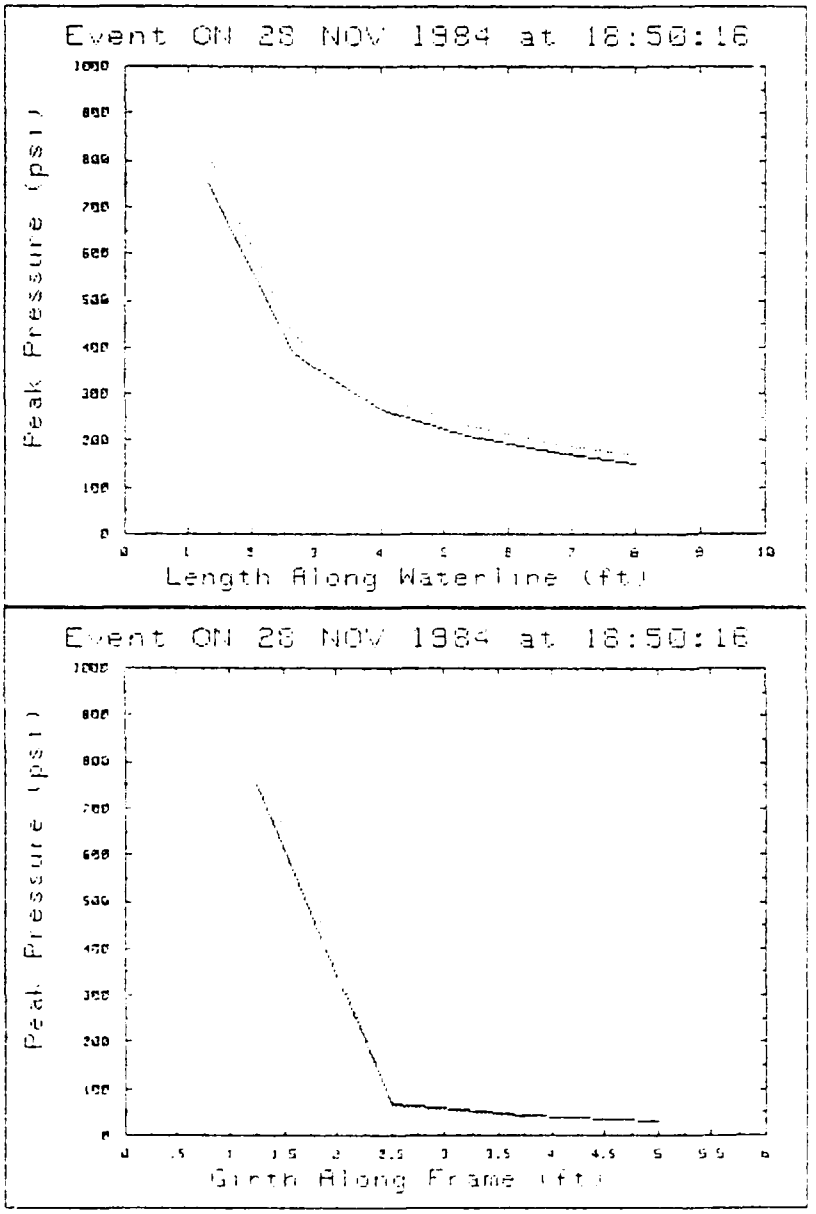
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

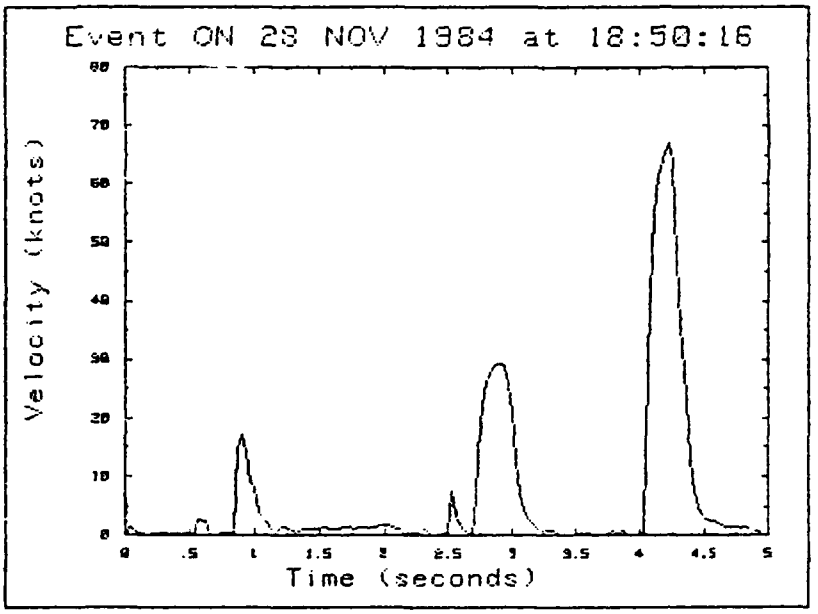
GIRTH	1.25	2.50	3.75	5.00
PRESSURE	749.00	69.00	42.00	32.00

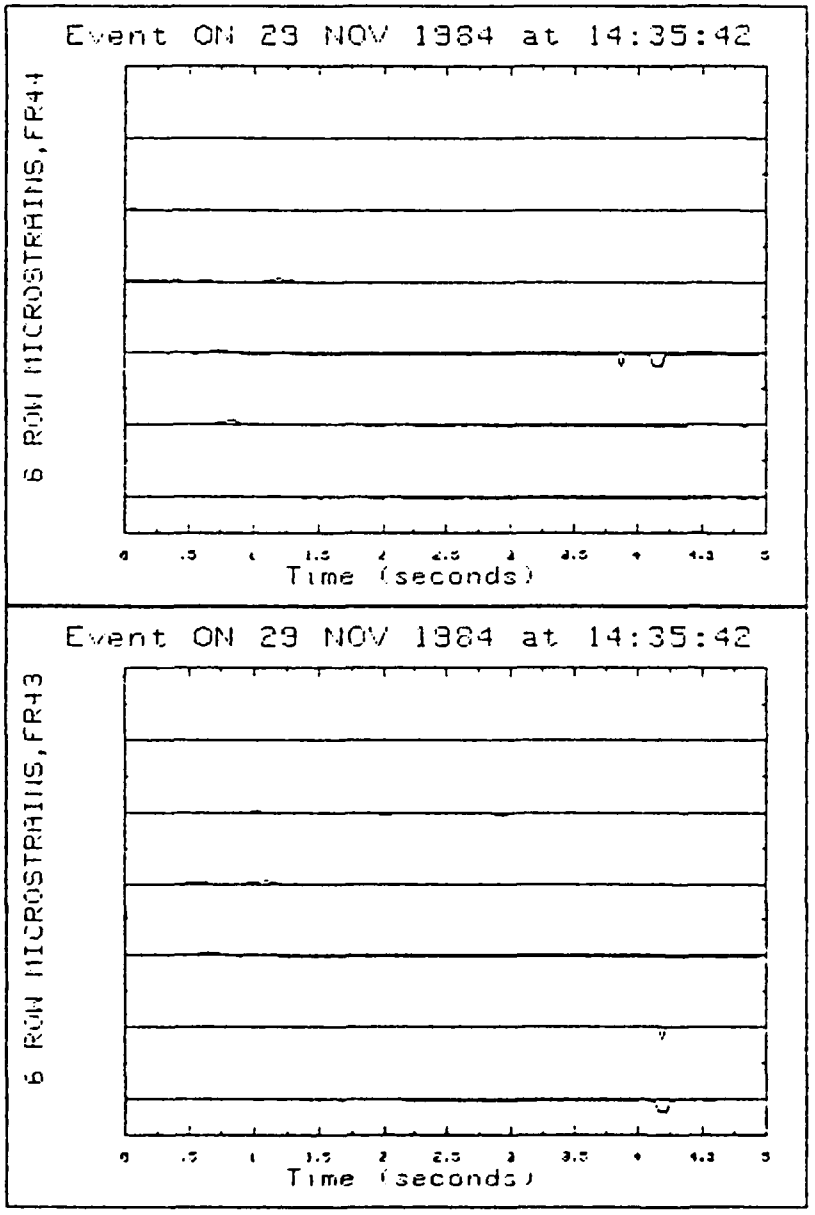
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

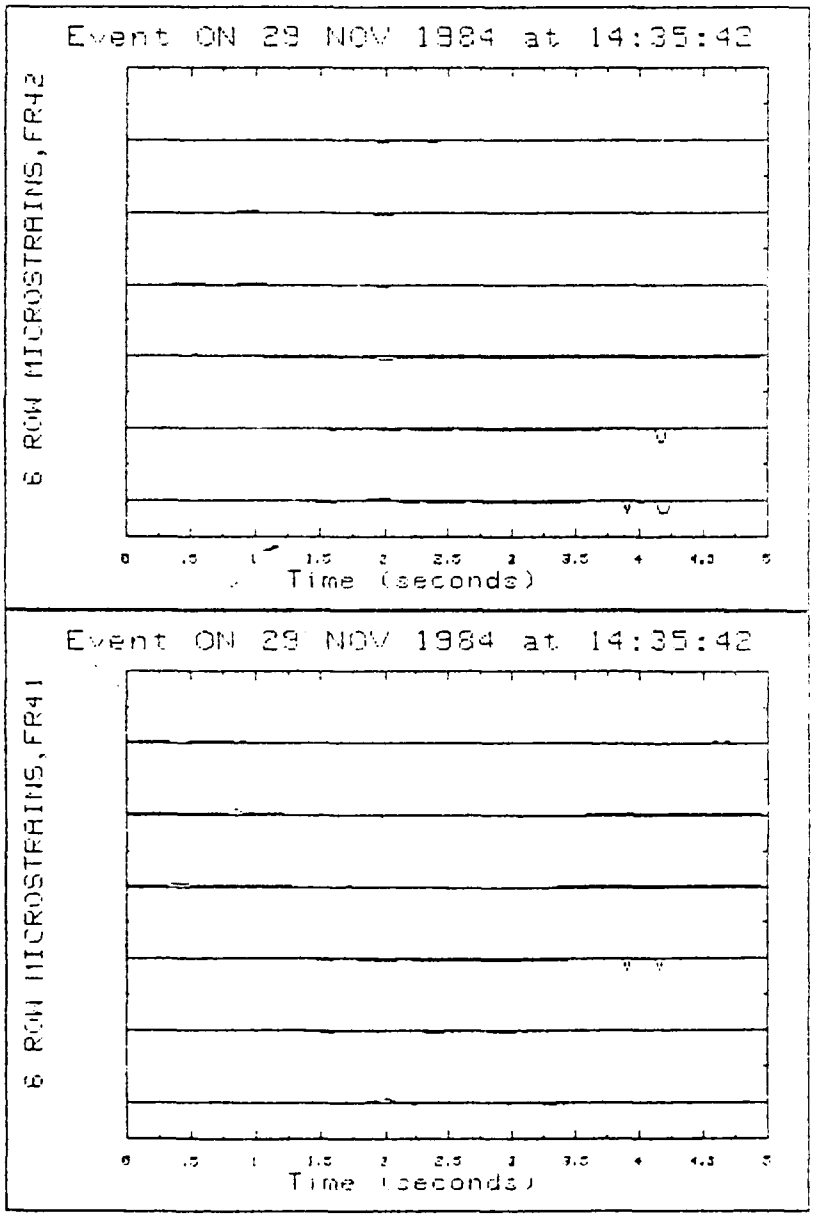
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00
PRESSURE	749.00	388.00	267.00	210.00	175.00	150.00

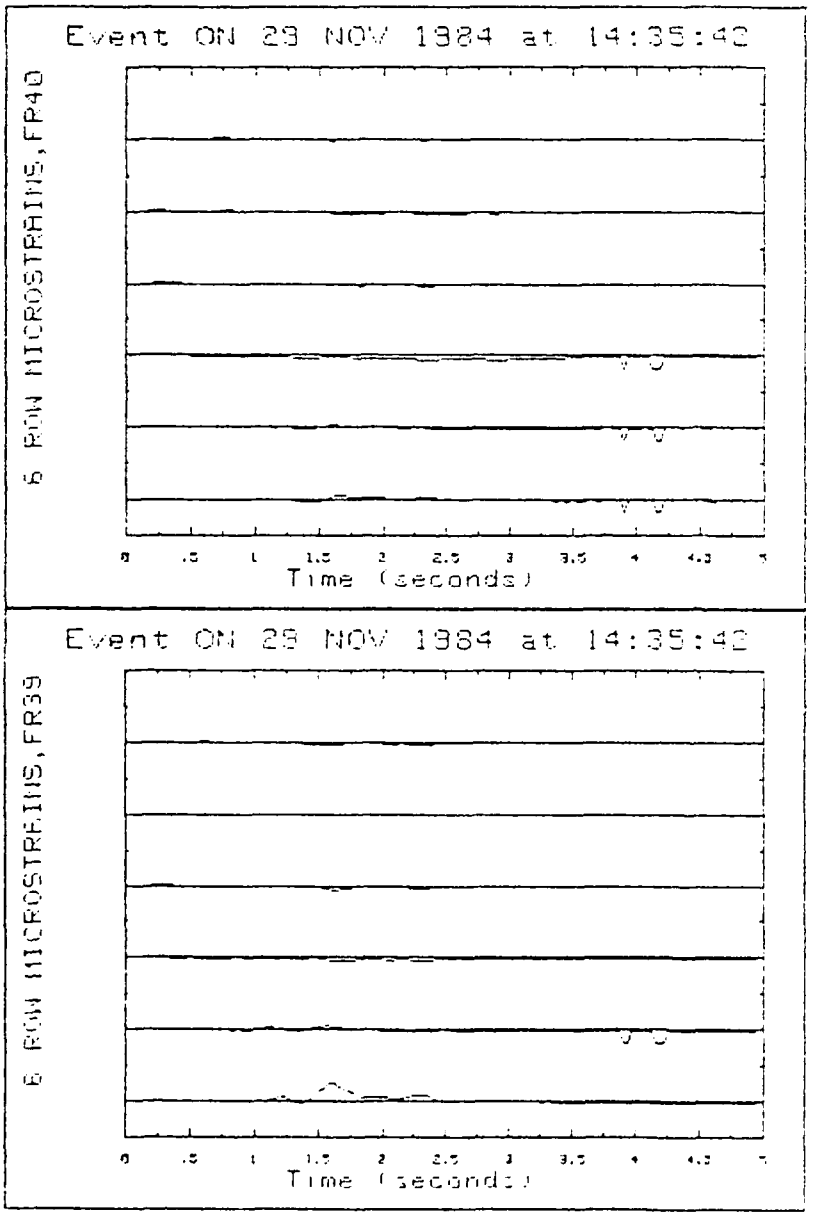

Event ON 28 NOV 1984 at 18:50:16
Total Force (long tons)
Time (seconds)
Event ON 28 NOV 1984 at 18:50:16
Pressure (psi)
1000
100
10
10

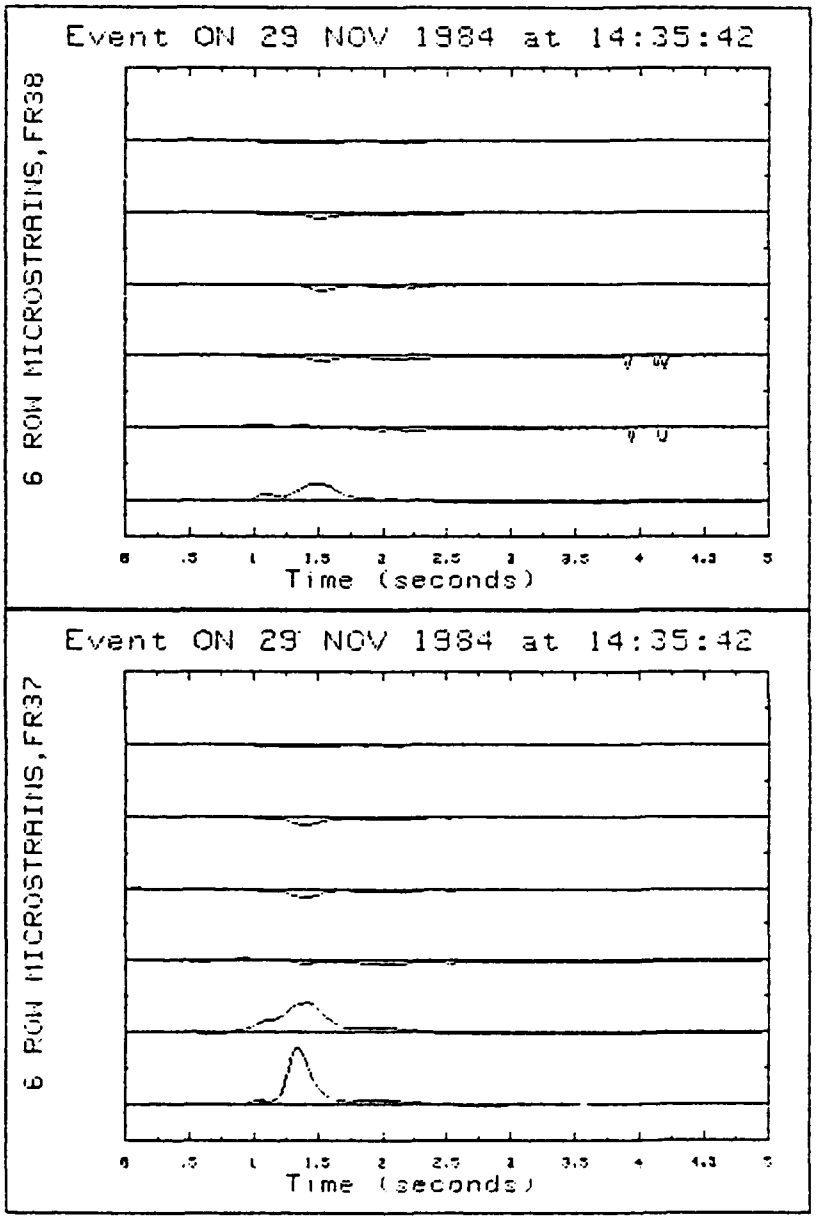

Event ON 28 NOV 1984 at 18:50:16
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 28 NOV 1984 at 18:50:16
Peak Pressure (psi)
Girth Along Frame (ft)

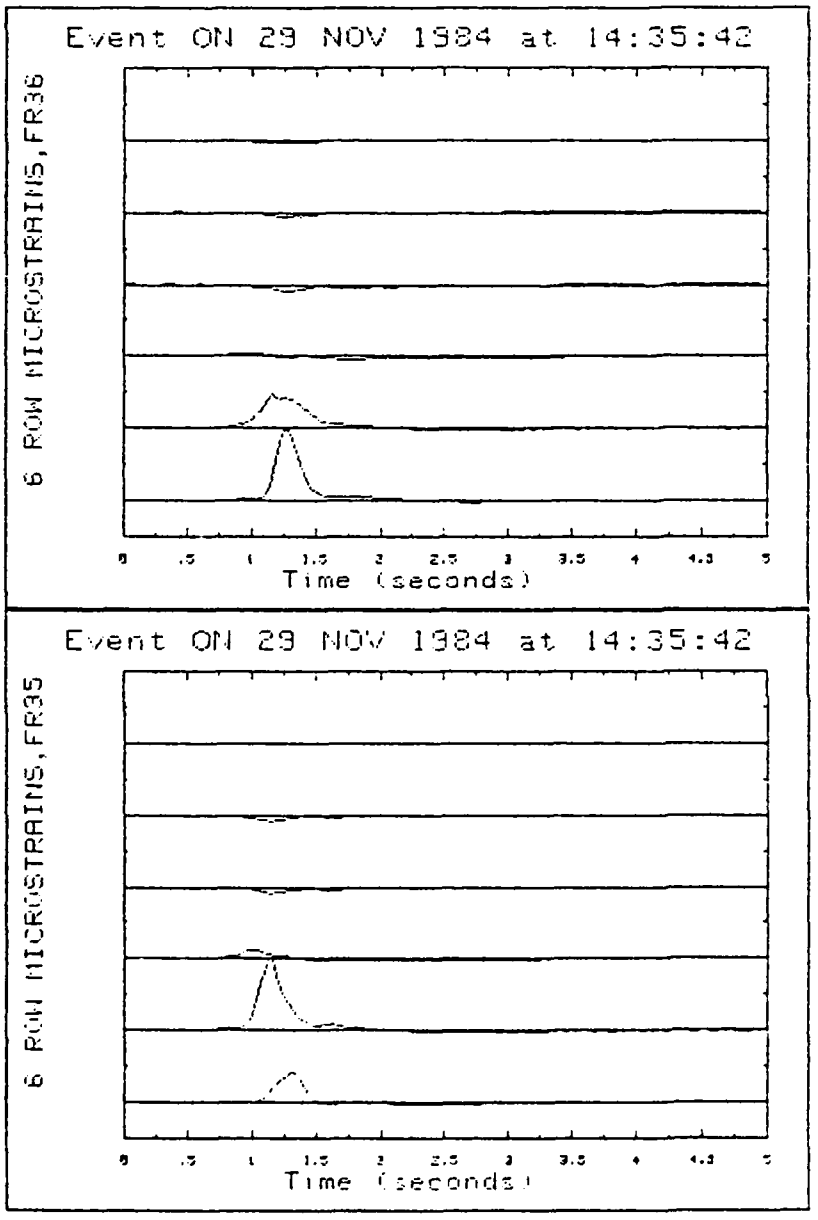

Event ON 28 NOV 1984 at 18:50:16
Velocity (knots)
80
70
60
50
40
30
20
10
0
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)

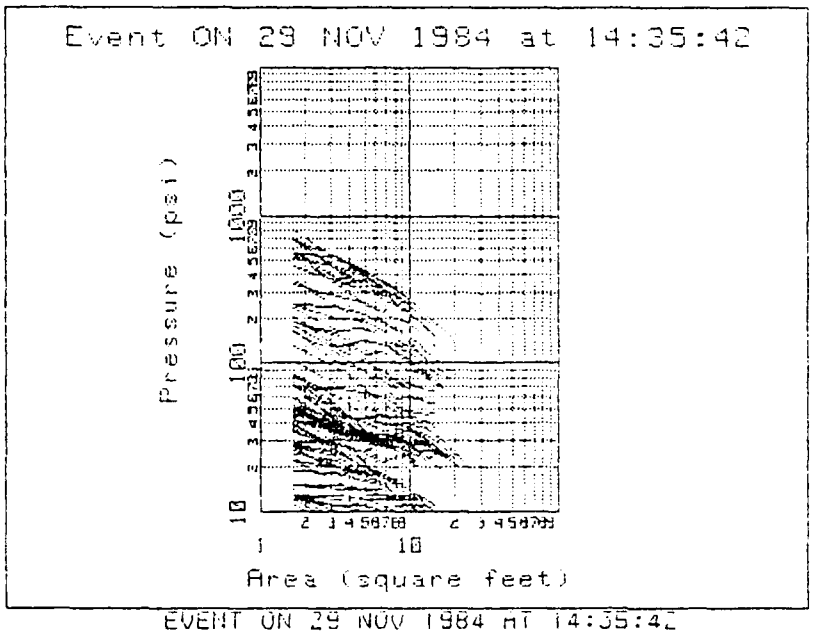

Event ON 29 NOV 1984 at 14:35:42
6 RDW MICROSTRAINS,FR44
Time (seconds)
Event ON 29 NOV 1984 at 14:35:42
6 RDW MICROSTRAINS,FR43
Time (seconds)


Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 28 NOV 1984 at 14:35:42
6 RMW MICROSTRAINS,FR40
Time (seconds)
Event ON 28 NOV 1984 at 14:35:42
6 RMW MICROSTRAINS,FR39
Time (seconds)


Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 29 NOV 1984 at 14:35:42
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 29 NOV 1984 AT 14:35:42
TAPE NUMBER 3 ; TRACK NUMBER 1 ; FILE NUMBER 16
PEAK STRAIN 381 ; THRESHOLD 150
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 796 PSI; TIME FRAME 36; REAL TIME 1.13
FRAME 35; ROW 7

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53
Pressure	796.00	507.00	374.00	293.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50
PRESSURE	796.00	133.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00
PRESSURE	796.00	507.00	374.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 183 LONG TONS; TIME FRAME 42; REAL TIME 1.31
FRAME 36; ROW 8

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	554.00	530.00	430.00	356.00	311.00	276.00	242.00

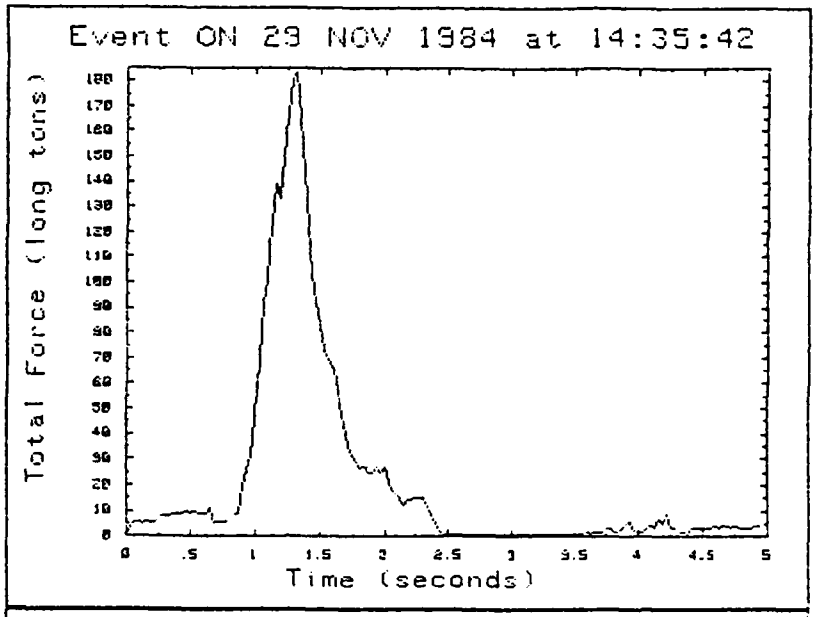
Area	13.06	14.69	16.32	17.95	19.58
Pressure	215.00	192.00	173.00	157.00	145.00

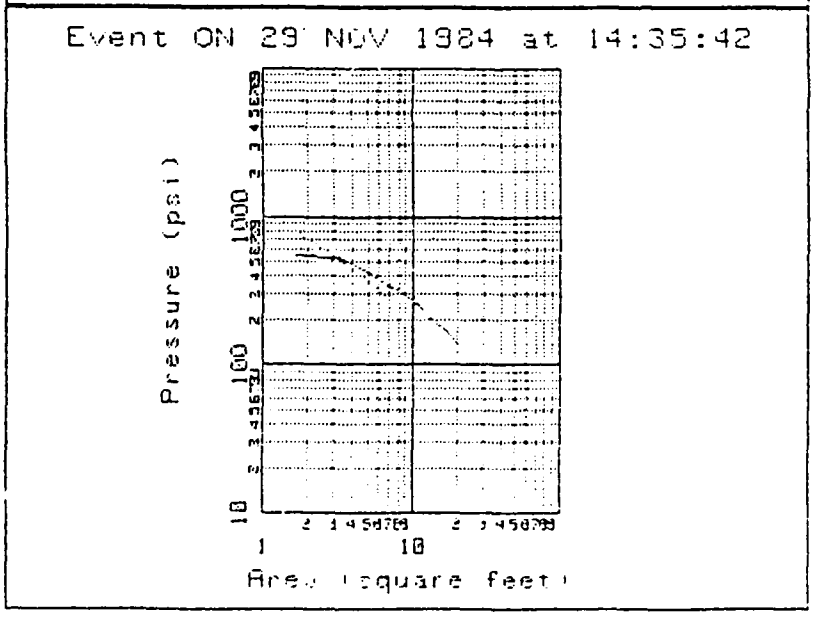
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

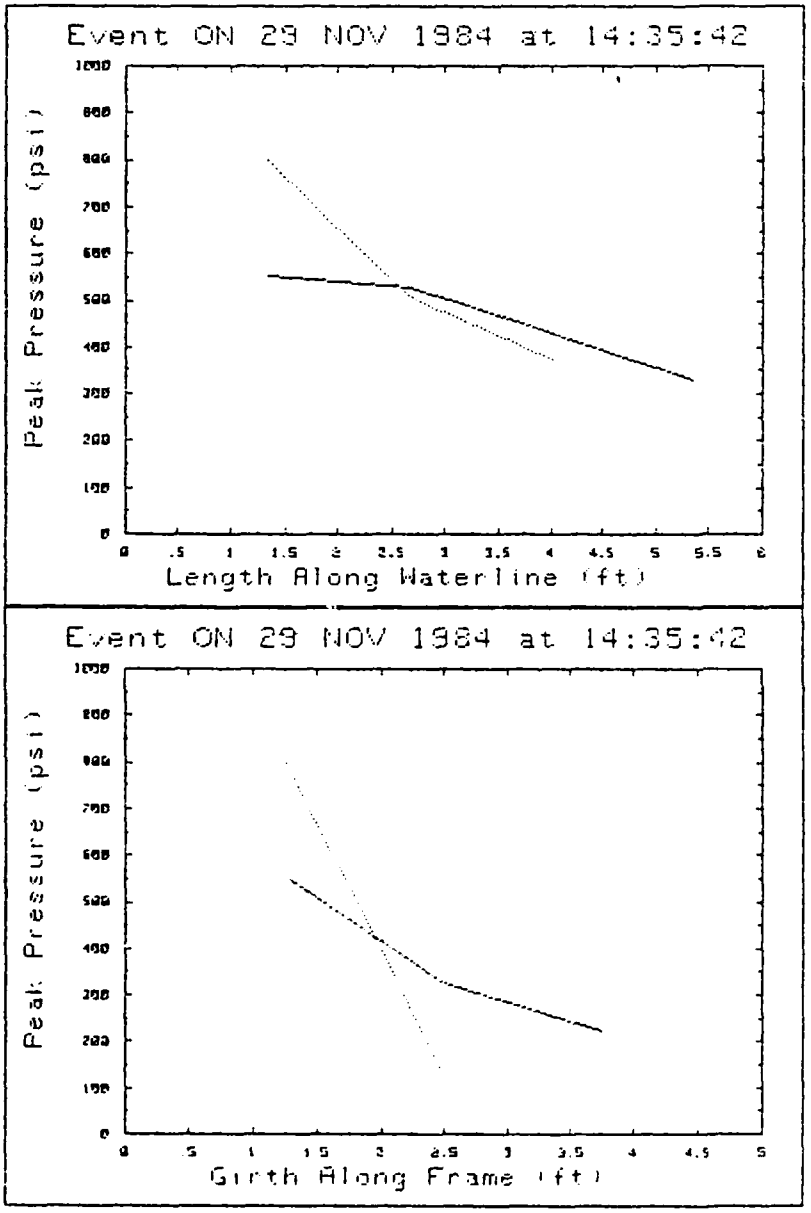
GIRTH	1.25	2.50	3.75
PRESSURE	554.00	327.00	225.00

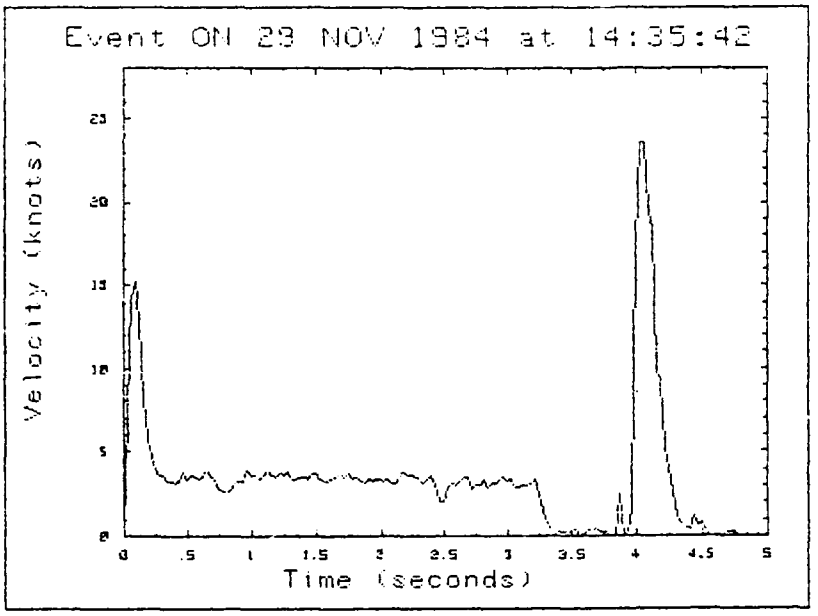
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33
PRESSURE	554.00	530.00	430.00	332.00


Event ON 29 NOV 1984 at 14:35:42
Total Force (long tons)
Time (seconds)

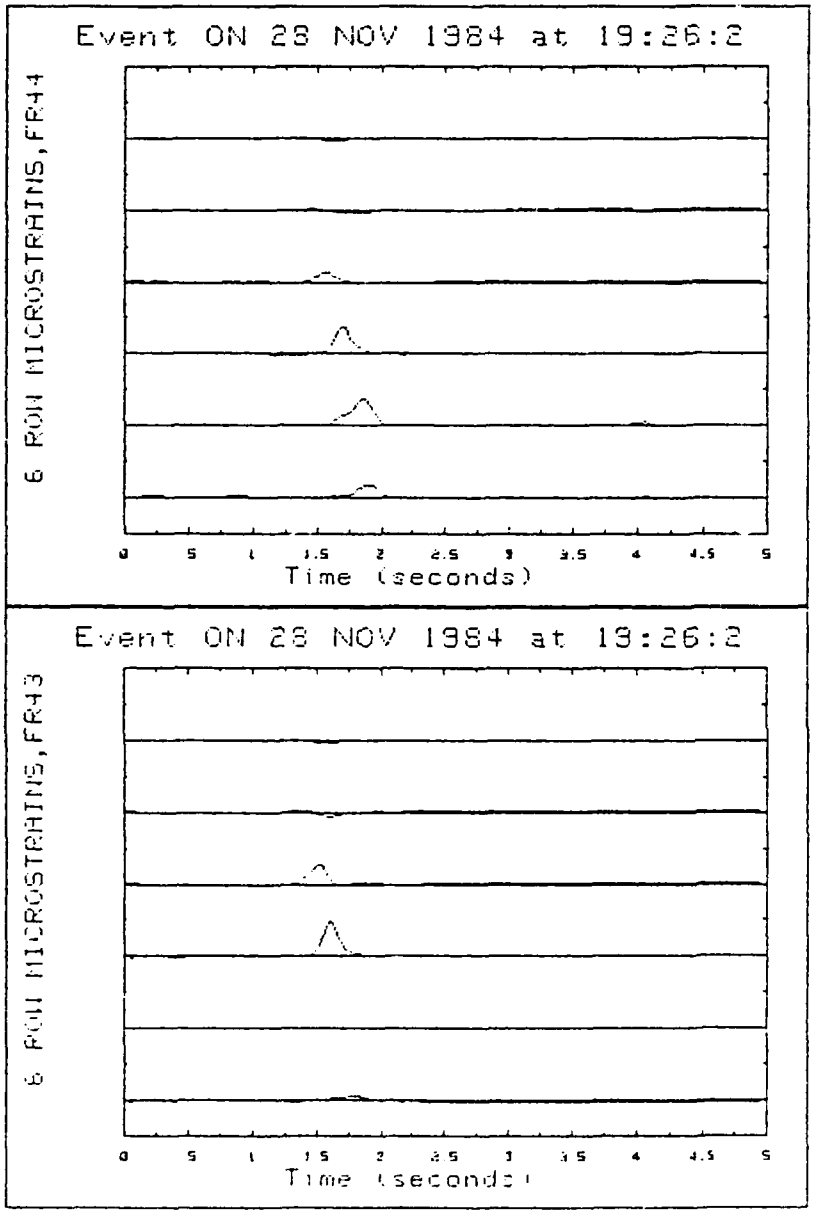

Event ON 29 NOV 1984 at 14:35:42
Pressure (psi)
1000
100
10
1
10
Area (square feet)


Event ON 29 NOV 1984 at 14:35:42
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 29 NOV 1984 at 14:35:42
Peak Pressure (psi)
Girth Along Frame (ft)

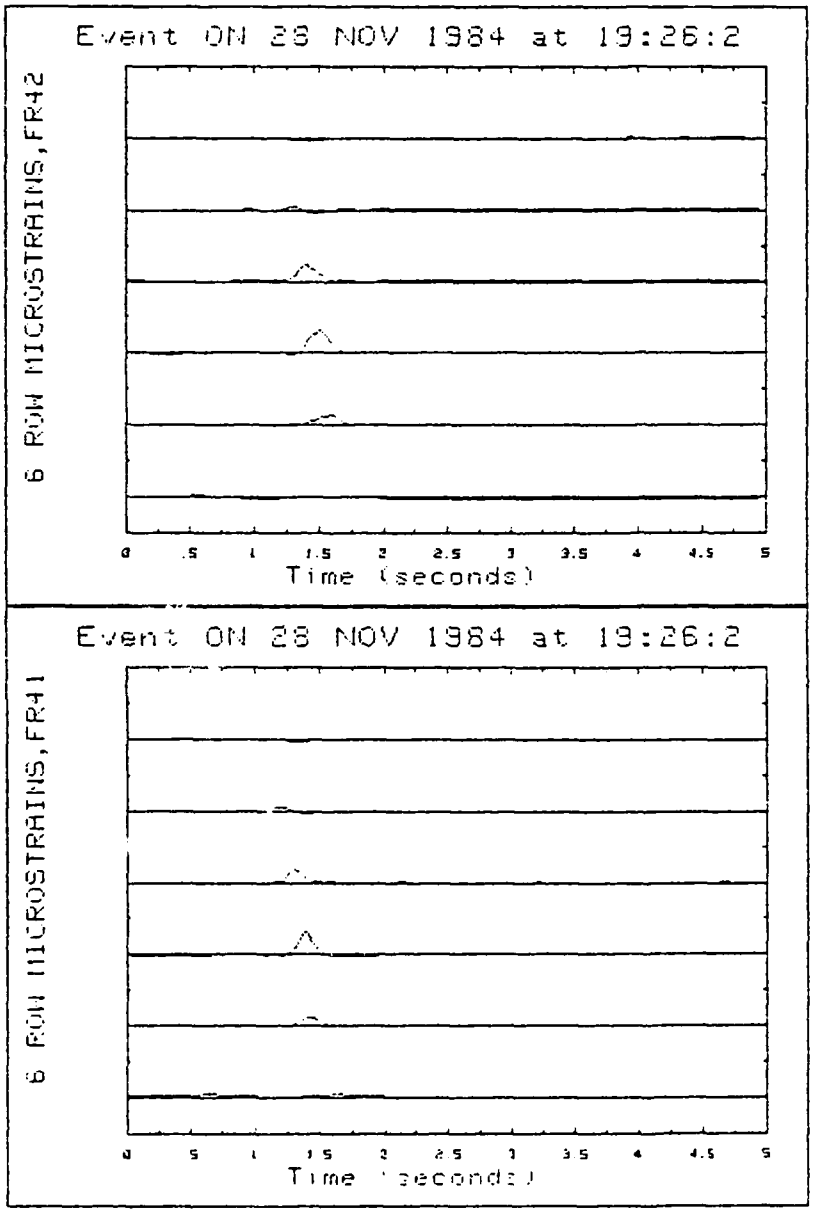

Event ON 23 NOV 1984 at 14:35:42
Velocity (knots)
Time (seconds)
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

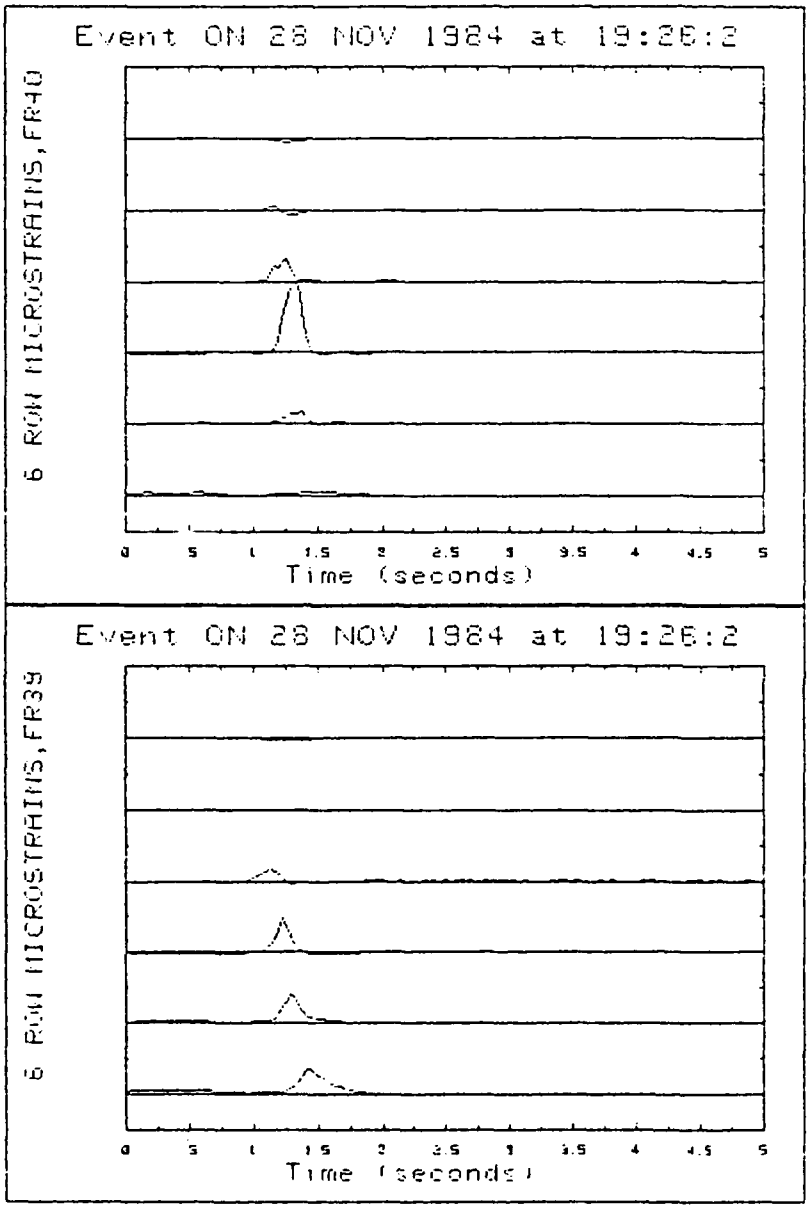
APPENDIX D

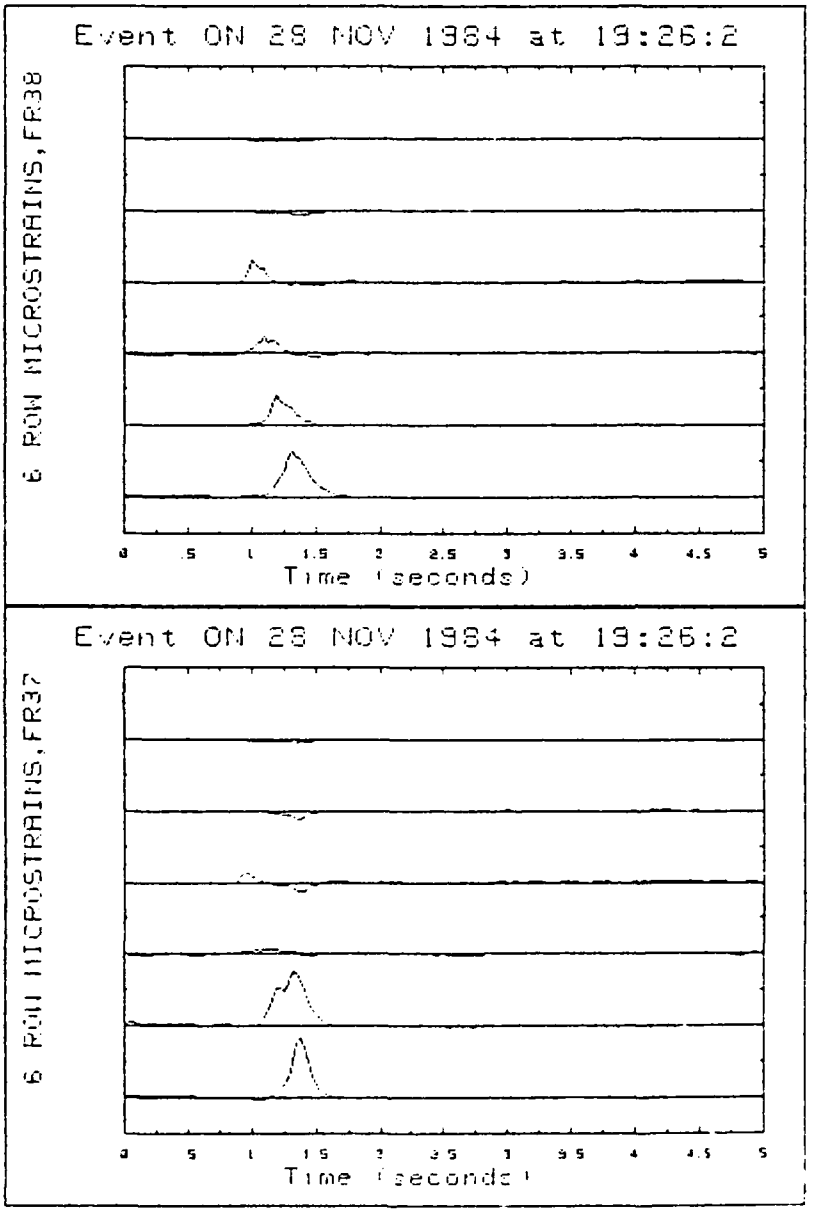
THE FIVE EVENTS OF HIGHEST PANEL FORCE

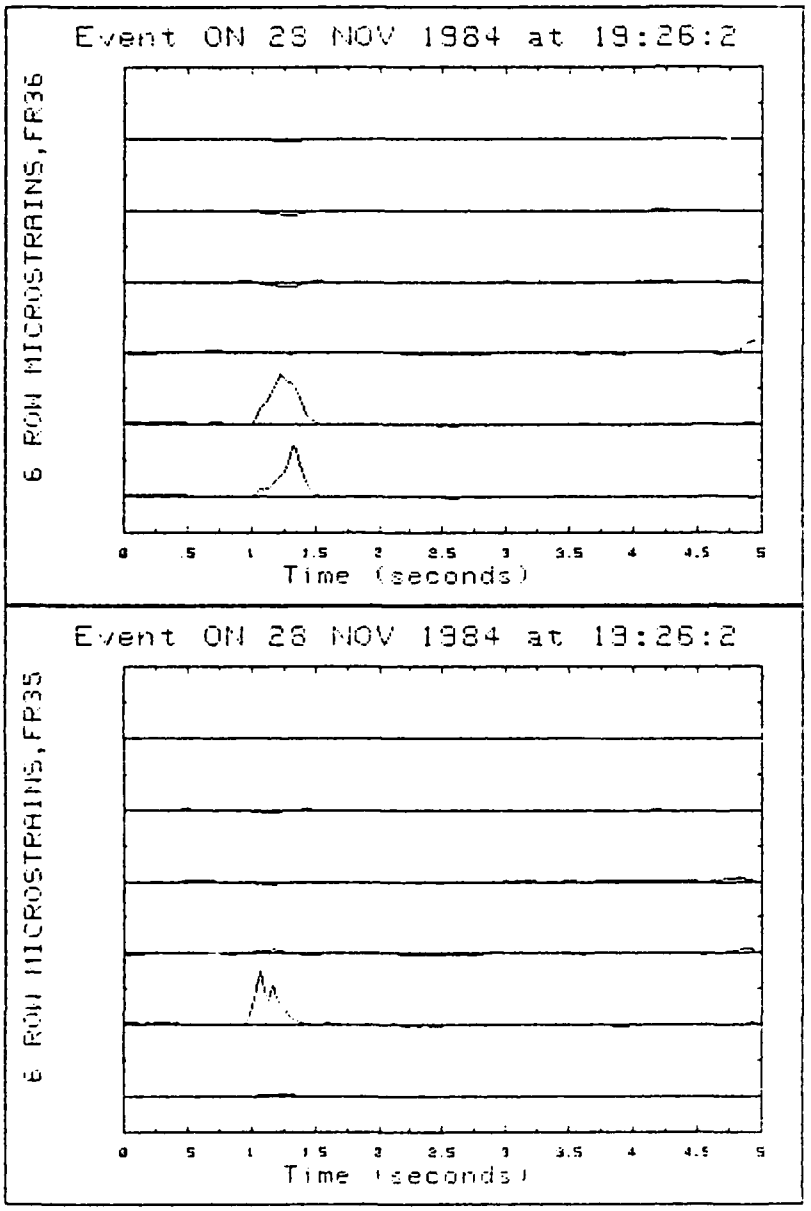


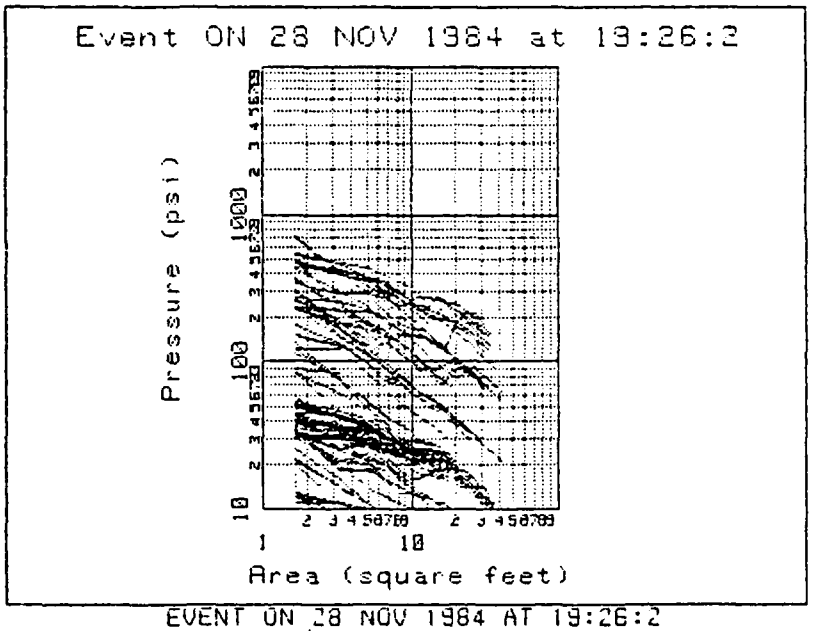
NOTE: Strain time-histories are normalized by the peak strain for the event.


Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR42
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR40
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR39
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR38
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS,FR37
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)


Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS, FR36
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)
Event ON 28 NOV 1984 at 19:26:2
6 ROW MICROSTRAINS, FR35
0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5
Time (seconds)



EVENT ON 28 NOV 1984 AT 19:26:2
TAPE NUMBER 2 ; TRACK NUMBER 4 ; FILE NUMBER 48
PEAK STRAIN 416 ; THRESHOLD 175
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 785 PSI; TIME FRAME 42; REAL TIME 1.31
FRAME 40; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area 1.63
Pressure 785.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH 1.25
PRESSURE 785.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH 1.33
PRESSURE 785.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 367 LONG TONS; TIME FRAME 43; REAL TIME 1.34
FRAME 40; ROW 6

AVERAGE PRESSURE (psi) vs AREA (square feet)

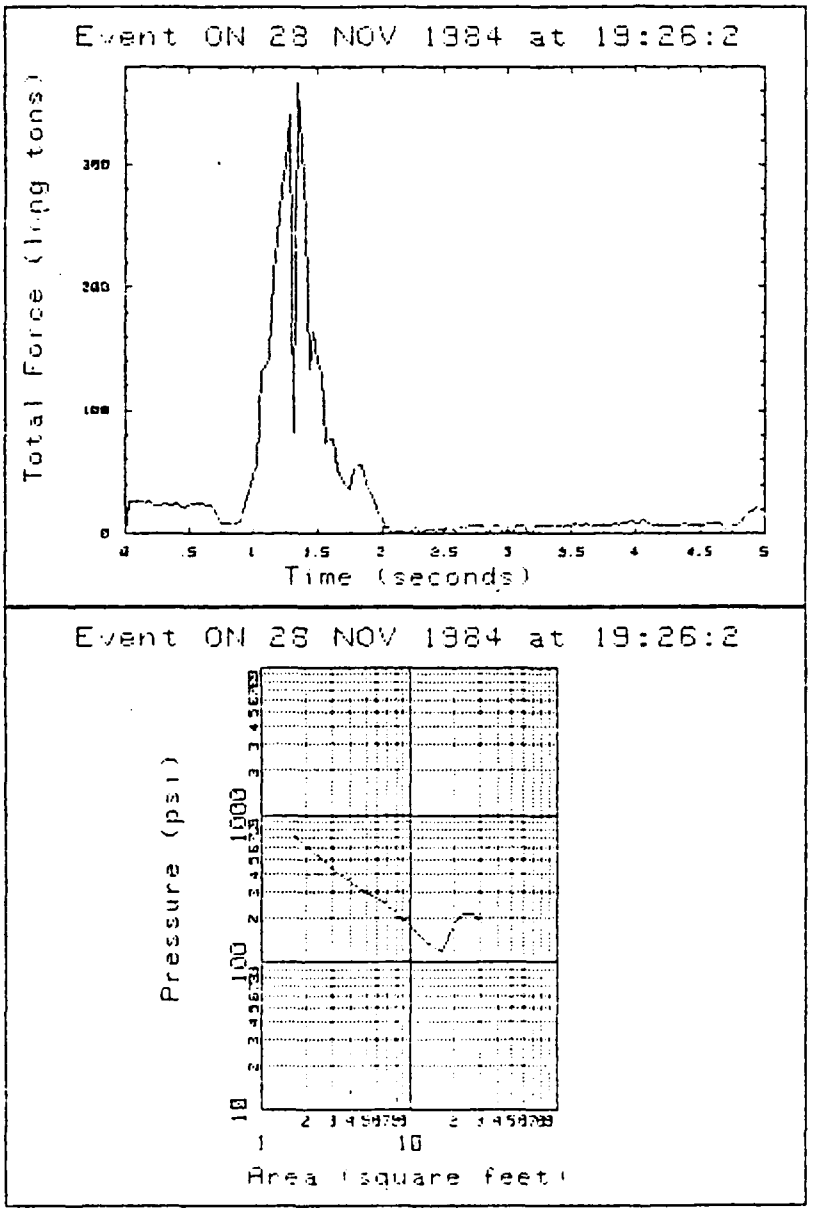
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	717.00	403.00	304.00	259.00	214.00	182.00	158.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	139.00	125.00	118.00	146.00	172.00	195.00	214.00
Area	24.48	26.11	27.74	29.38	31.01		
Pressure	217.00	217.00	205.00	194.00	184.00		

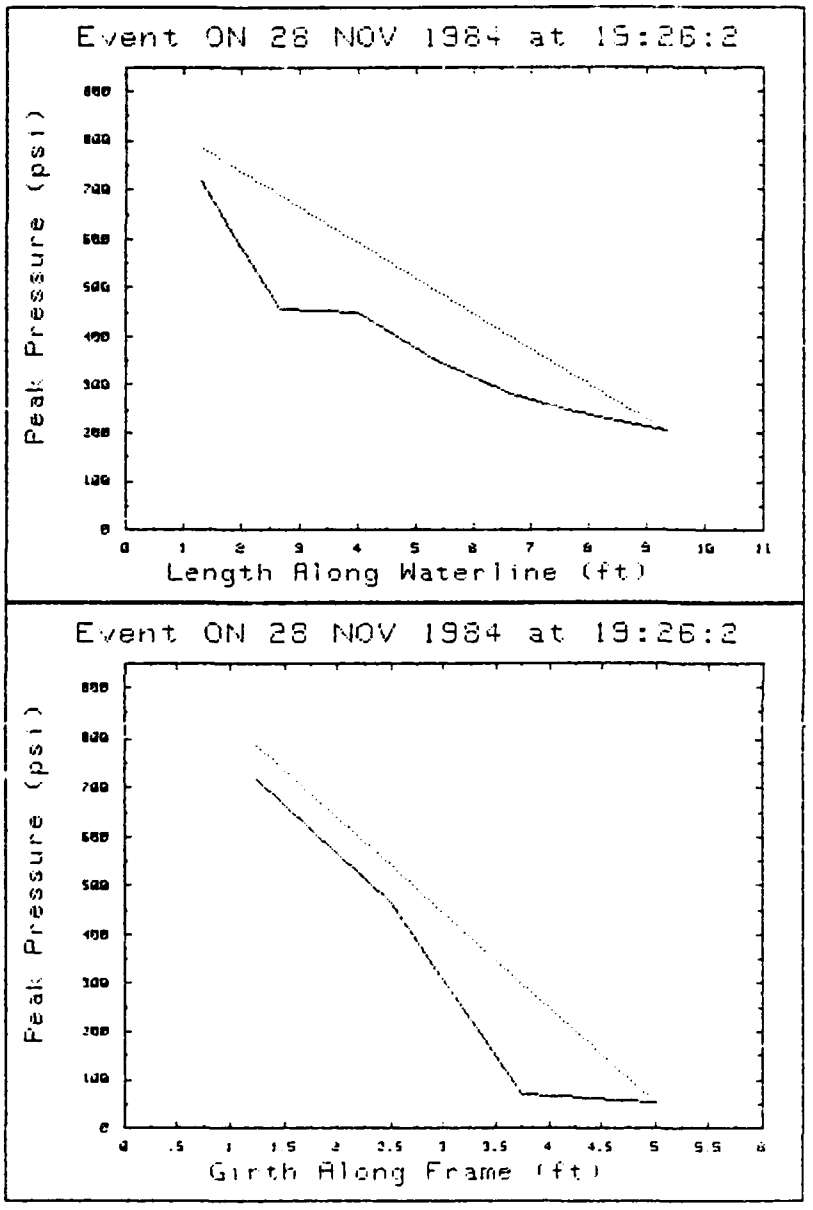
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

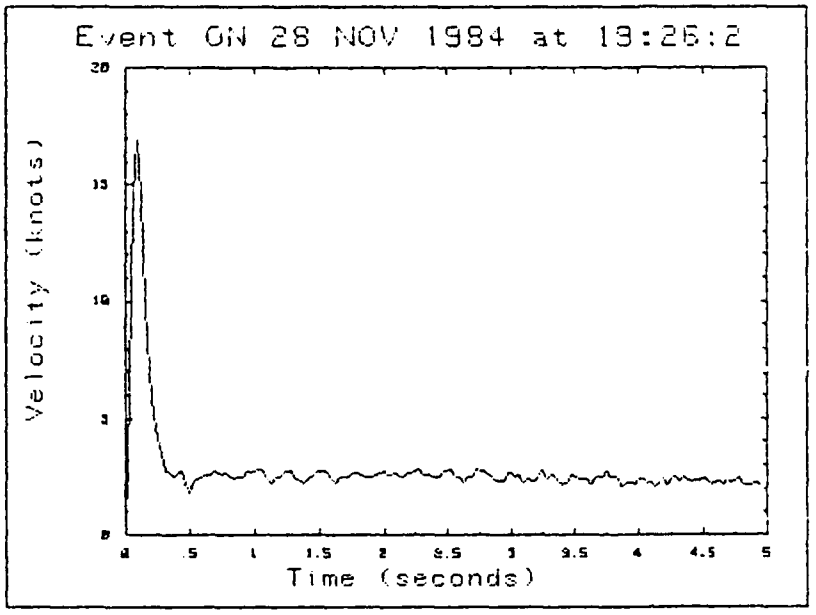
GIRTH	1.25	2.50	3.75	5.00
PRESSURE	717.00	463.00	70.00	53.00

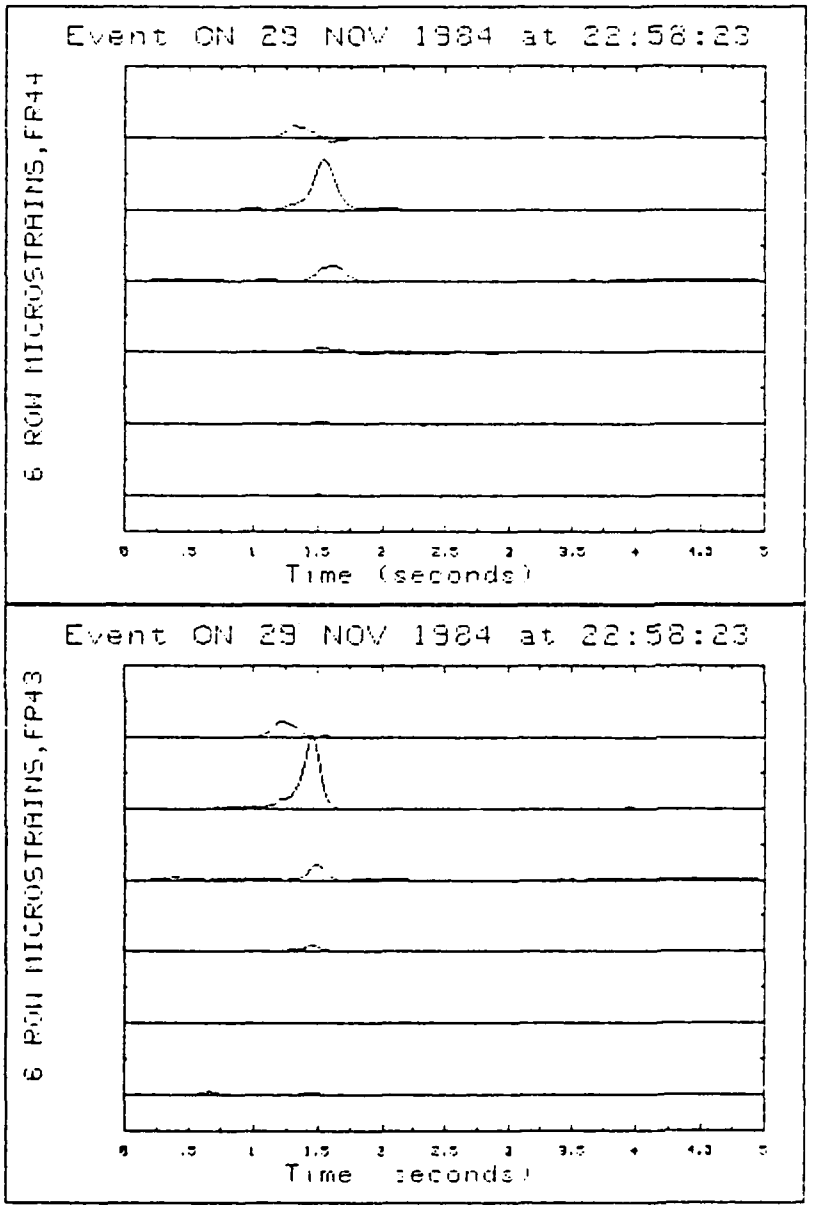
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

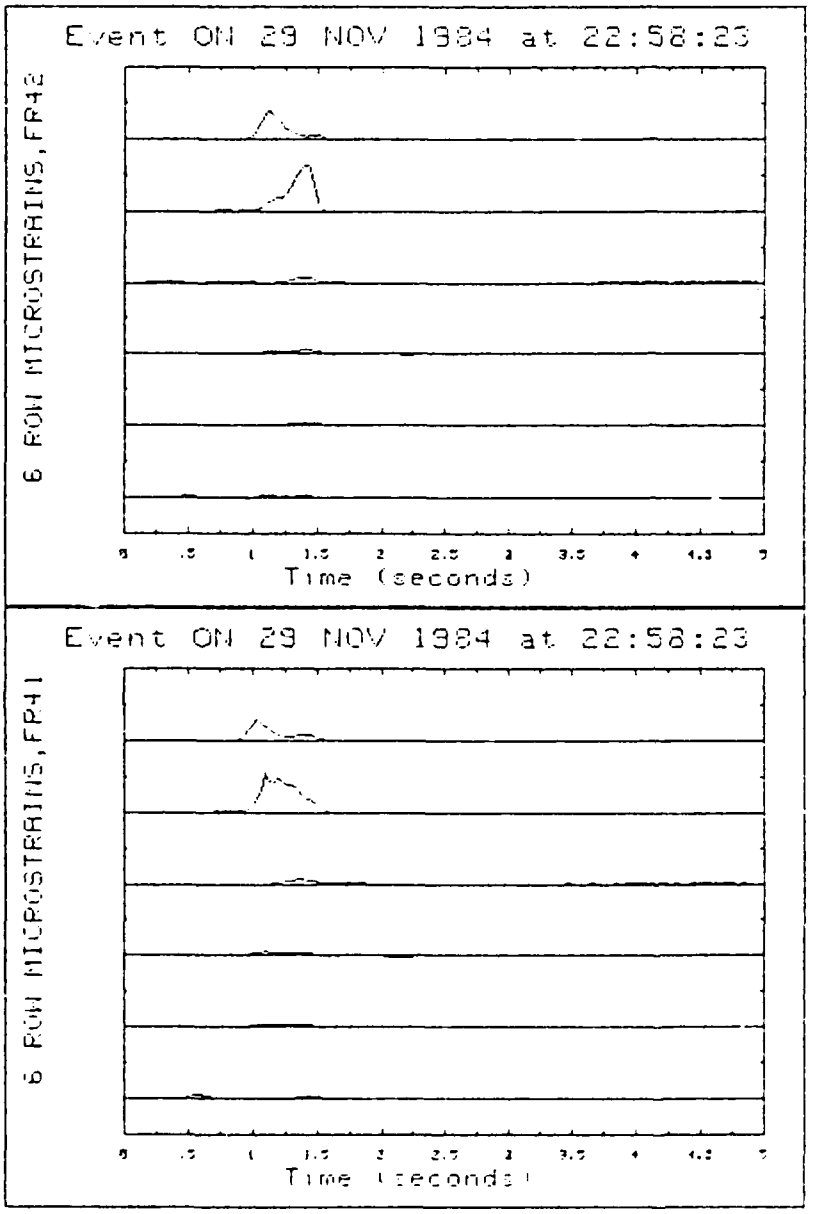
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	717.00	457.00	448.00	349.00	282.00	235.00	203.00

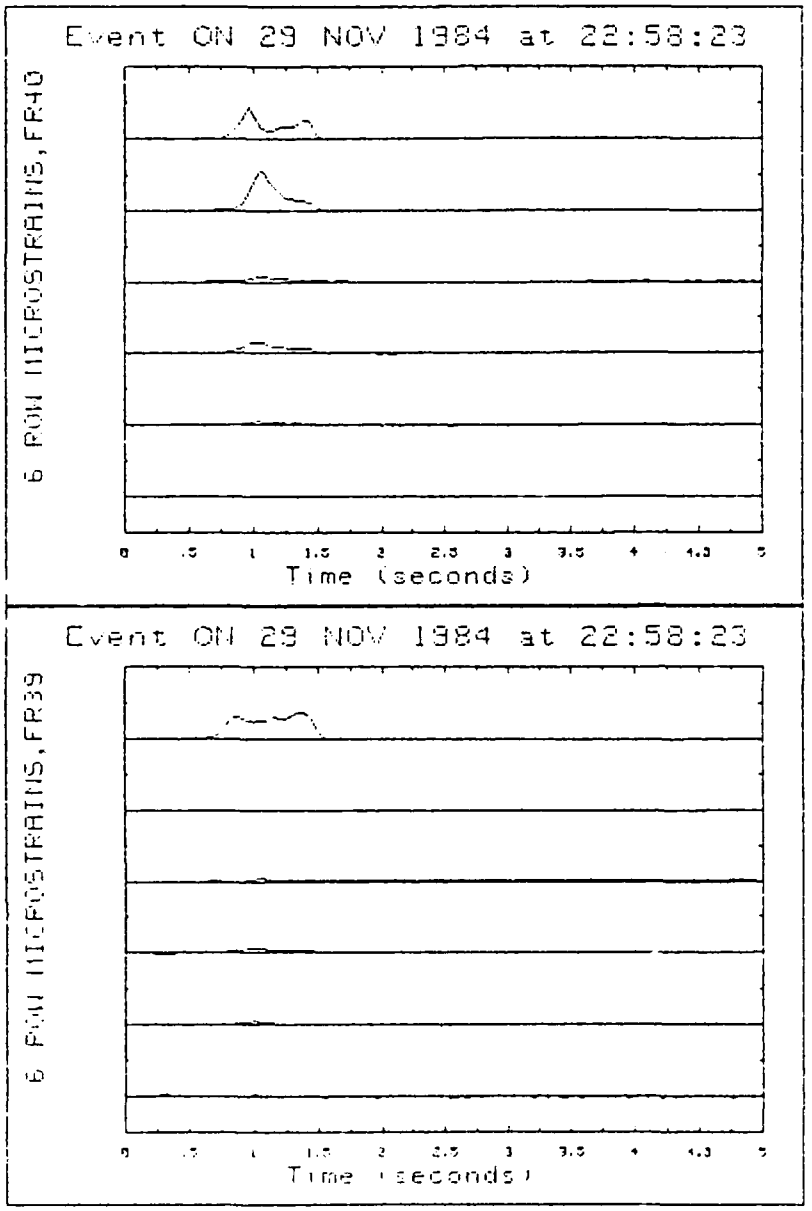

Event ON 28 NOV 1984 at 19:26:2
Total Force (long tons)
300
200
100
0
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 28 NOV 1984 at 19:26:2
Pressure (psi)
1000
100
10
1
10
Area (square feet)

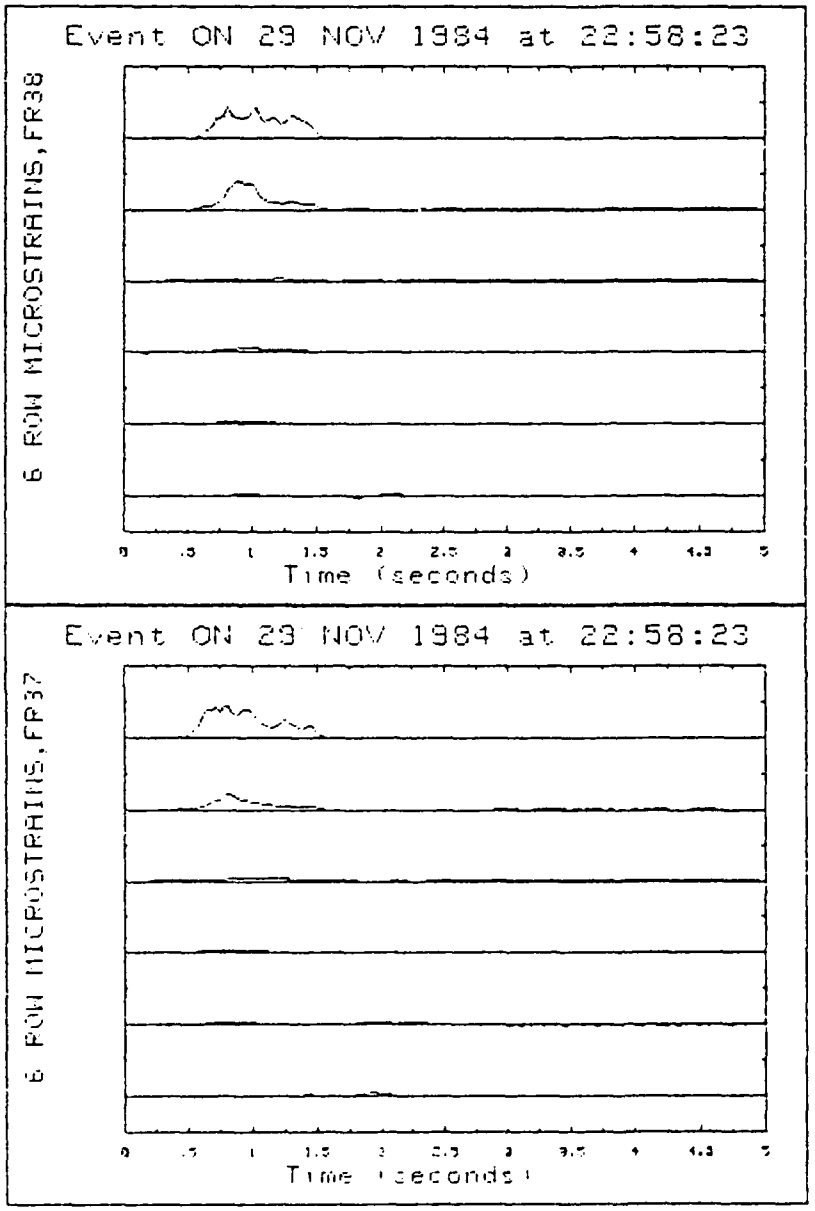

Event ON 28 NOV 1984 at 19:26:2
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 28 NOV 1984 at 19:26:2
Peak Pressure (psi)
Girth Along Frame (ft)

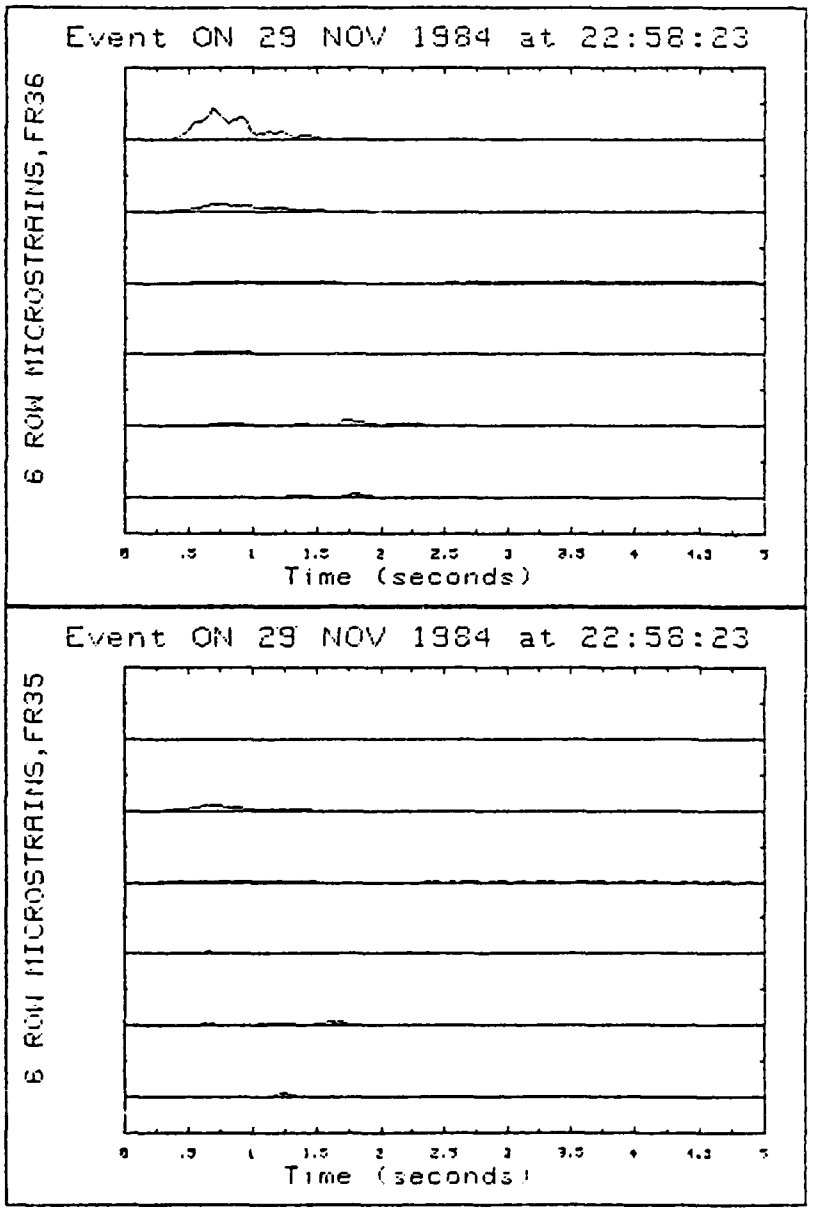

Event ON 28 NOV 1984 at 18:26:2
Velocity (knots)
20
15
10
5
0
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)

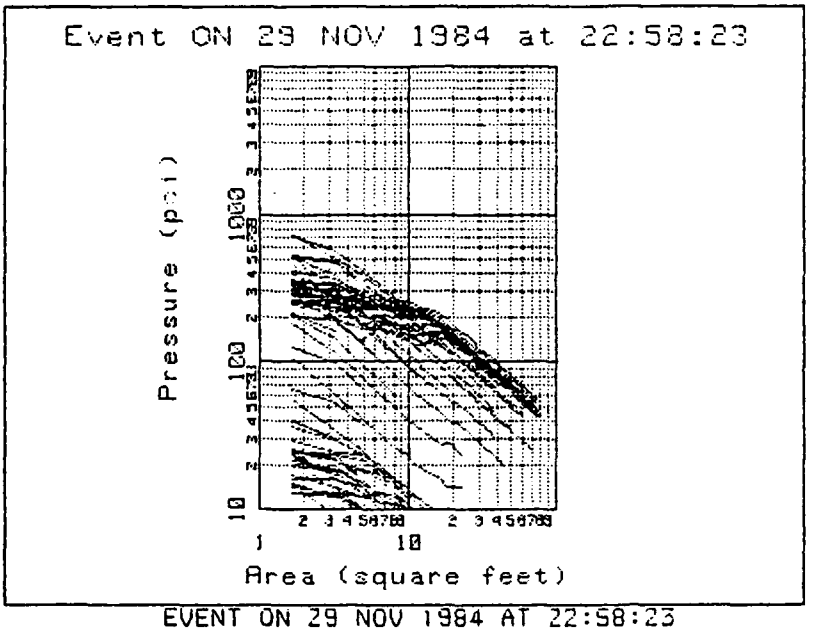

Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS, FP44
Time (seconds)
Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS, FP43
Time (seconds)


Event ON 29 NOV 1984 at 22:58:23
6 RDM MICROSTRAINS,FP42
Time (seconds)
Event ON 29 NOV 1984 at 22:58:23
6 RDM MICROSTRAINS,FP41
Time (seconds)


Event ON 29 NOV 1984 at 22:58:23
6 POW MICROSTRAINS,FR40
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 29 NOV 1984 at 22:58:23
6 POW MICROSTRAINS,FR39
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)


Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 29 NOV 1984 at 22:58:23
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 29 NOV 1984 AT 22:58:23
TAPE NUMBER 3 ; TRACK NUMBER 1 ; FILE NUMBER 72
PEAK STRAIN 285 ; THRESHOLD 150
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 729 PSI; TIME FRAME 46; REAL TIME 1.44
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	729.00	559.00	412.00	329.00	278.00	241.00	229.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	231.00	219.00	209.00	194.00	181.00	169.00	159.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	150.00	141.00	133.00	126.00	120.00	115.00	112.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	108.00	104.00	100.00	96.00	93.00	90.00	87.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	84.00	81.00	79.00	77.00	75.00	73.00	71.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	70.00	68.00	67.00	65.00	63.00	62.00	61.00
Area	70.17	71.81	73.44	75.07			
Pressure	59.00	58.00	57.00	56.00			

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	729.00	373.00	44.00	36.00	29.00	28.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	729.00	559.00	412.00	327.00	268.00	124.00	111.00

LENGTH	10.67	12.00
PRESSURE	105.00	97.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 270 LONG TONS; TIME FRAME 46; REAL TIME 1.44
FRAME 43; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

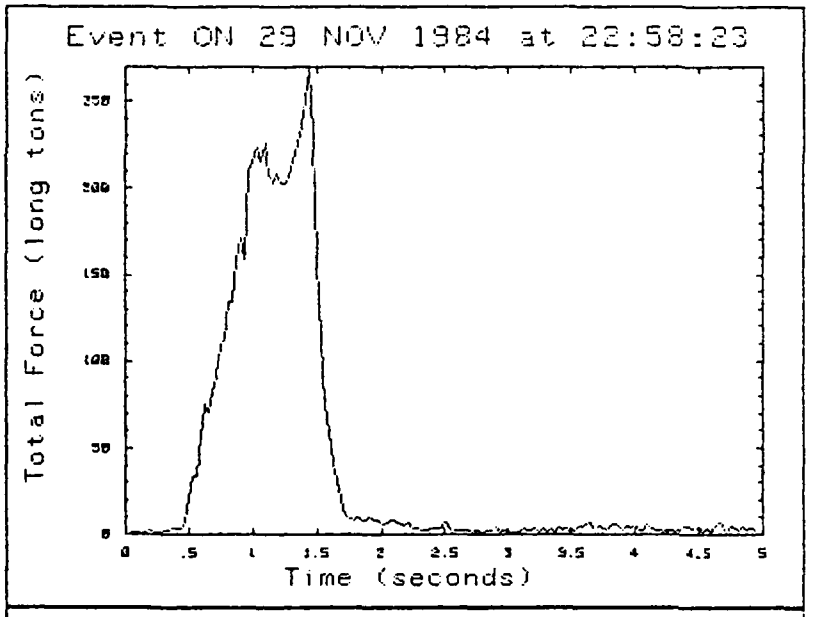
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	729.00	559.00	412.00	329.00	278.00	241.00	229.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	231.00	219.00	209.00	194.00	181.00	169.00	159.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	150.00	141.00	133.00	126.00	120.00	115.00	112.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	108.00	104.00	100.00	96.00	93.00	90.00	87.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	84.00	81.00	79.00	77.00	75.00	73.00	71.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	70.00	68.00	67.00	65.00	63.00	62.00	61.00
Area	70.17	71.81	73.44	75.07			
Pressure	59.00	58.00	57.00	56.00			

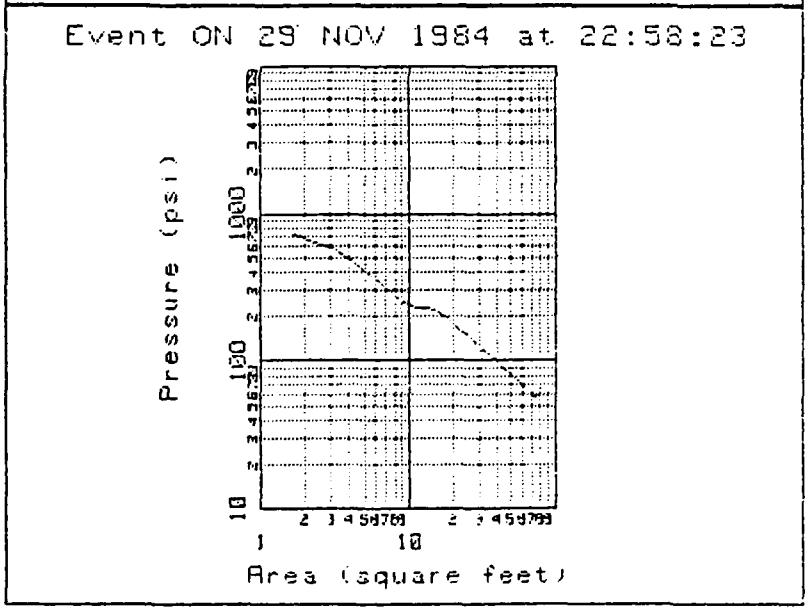
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

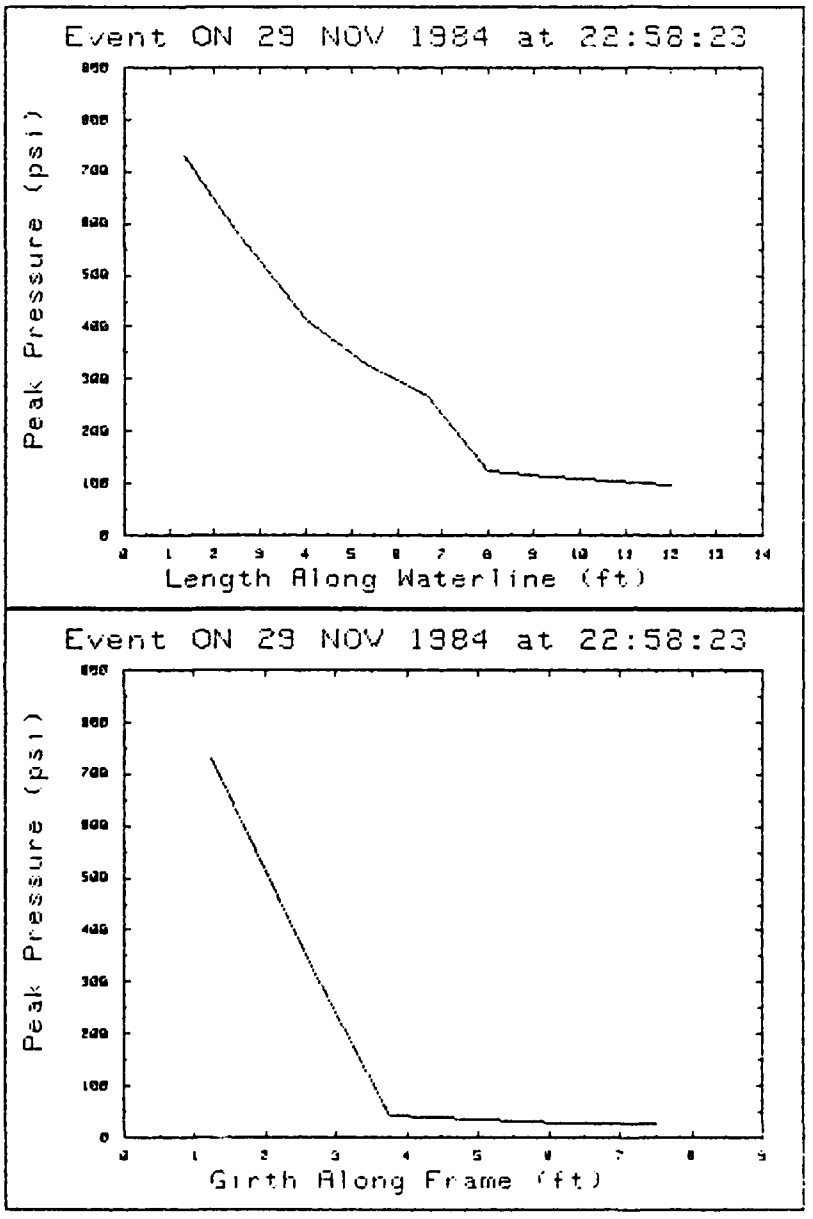
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	729.00	373.00	44.00	36.00	29.00	28.00

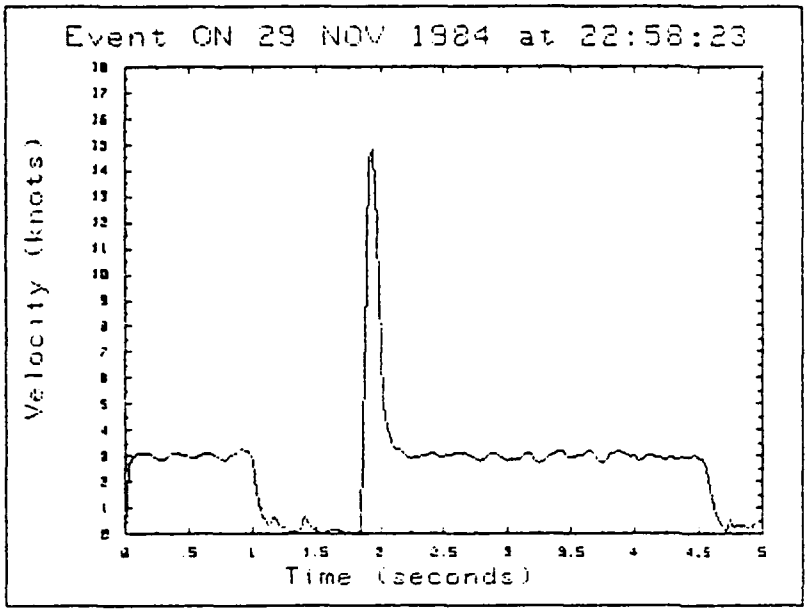
PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

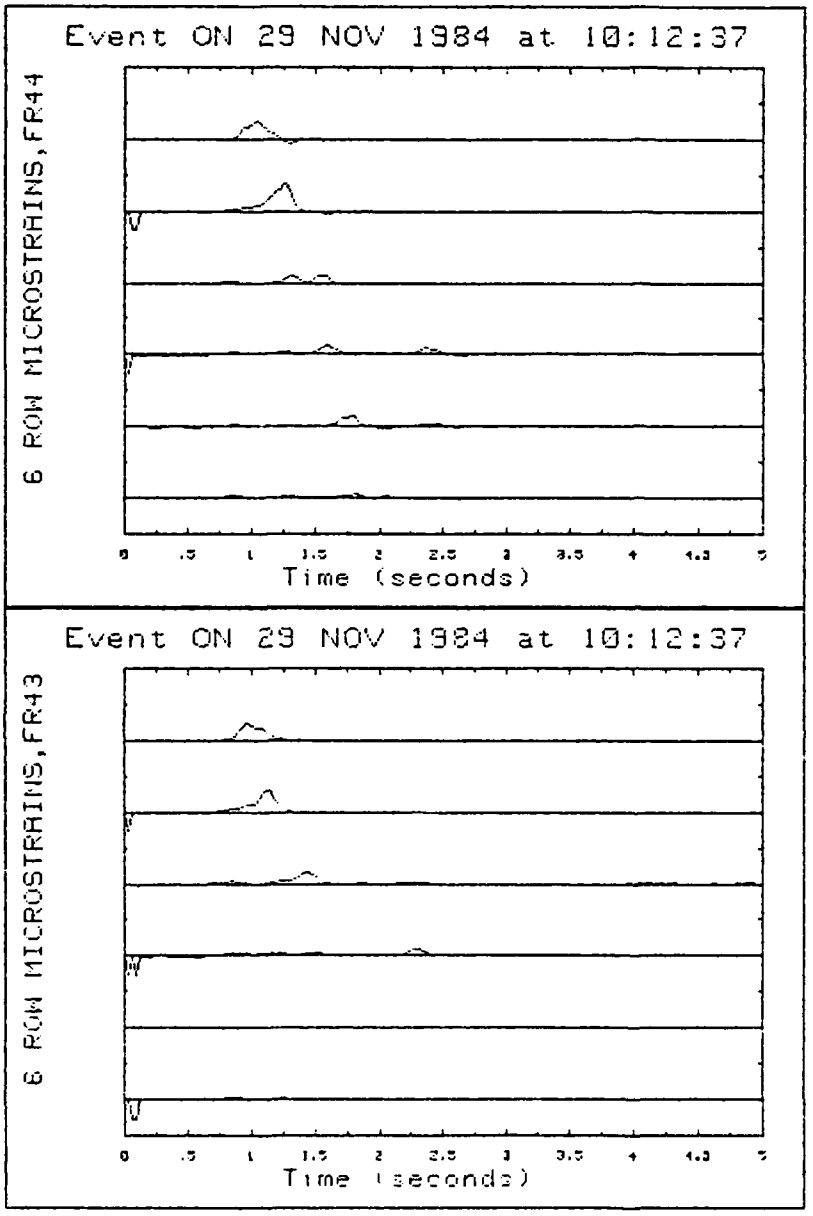
LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	729.00	559.00	412.00	327.00	268.00	124.00	111.00
LENGTH	10.67	12.00					
PRESSURE	105.00	97.00					

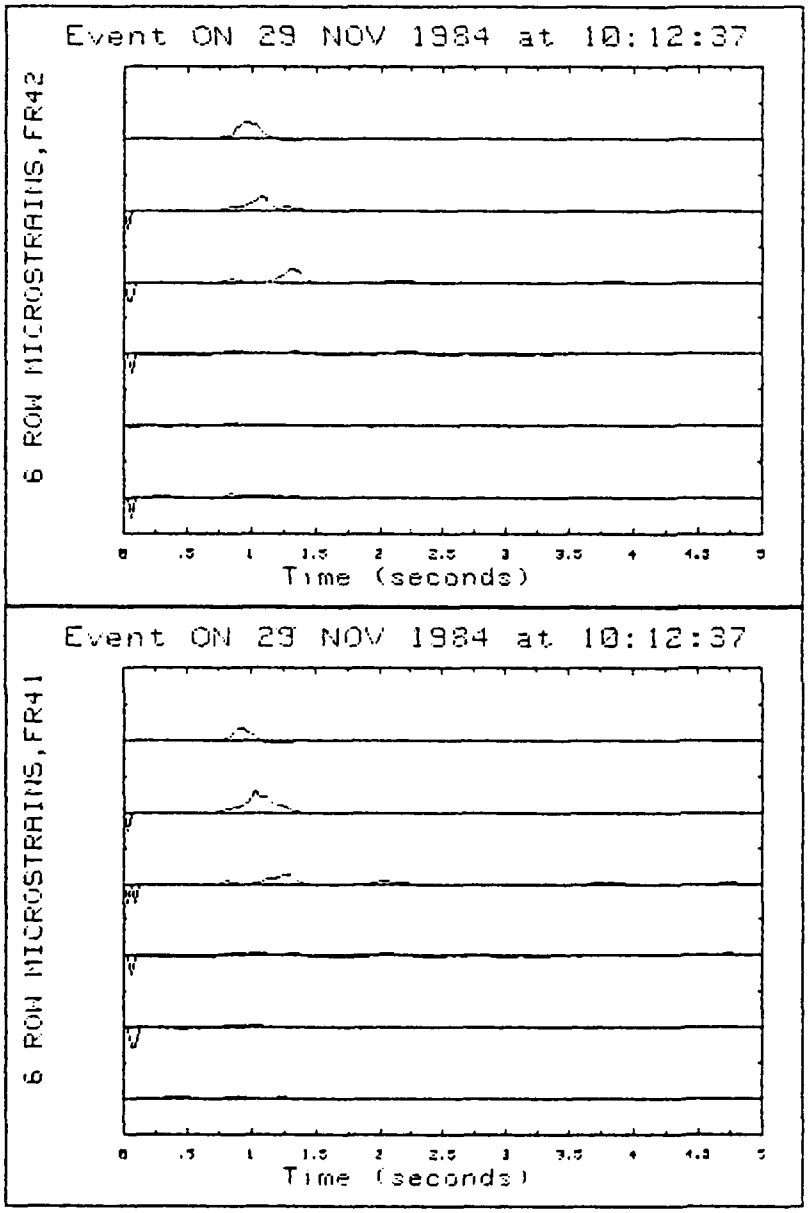

Event ON 29 NOV 1984 at 22:58:23
Total Force (long tons)
Time (seconds)

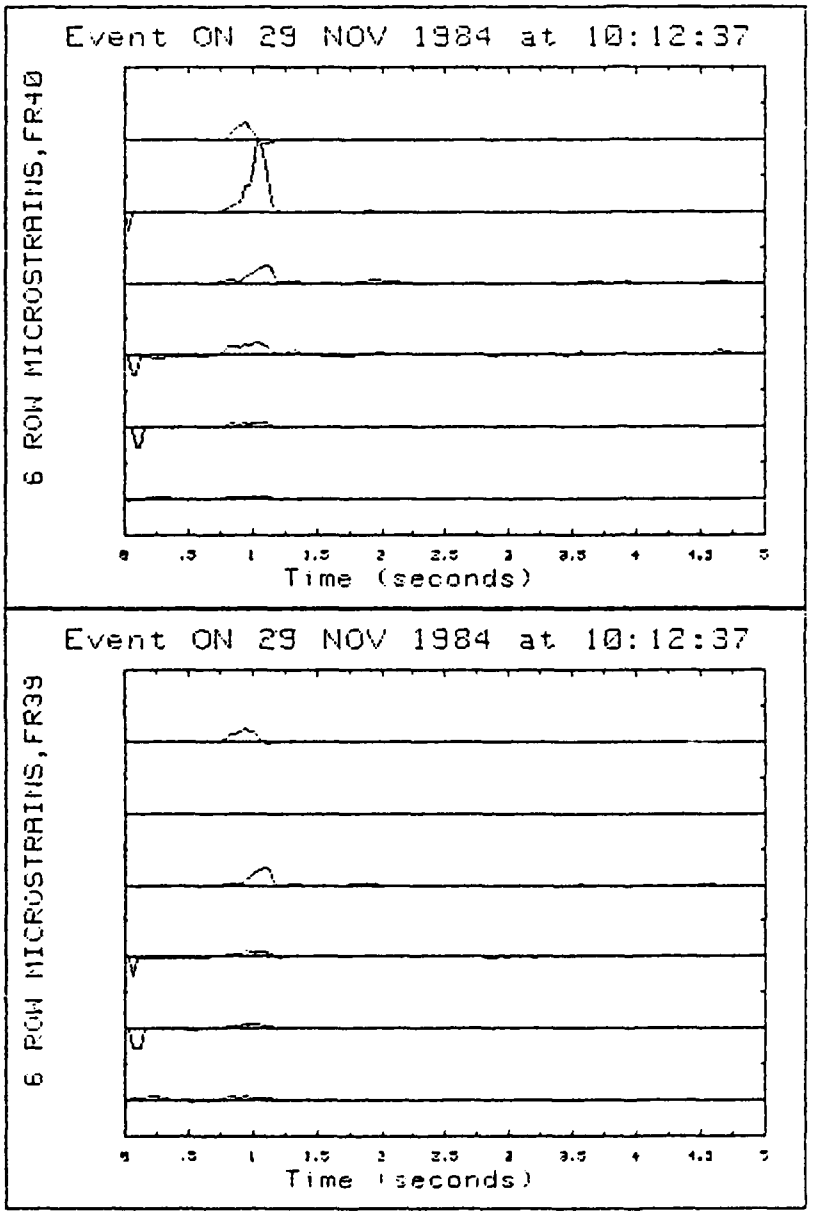

Event ON 29 NOV 1984 at 22:58:23
Pressure (psi)
Area (square feet)

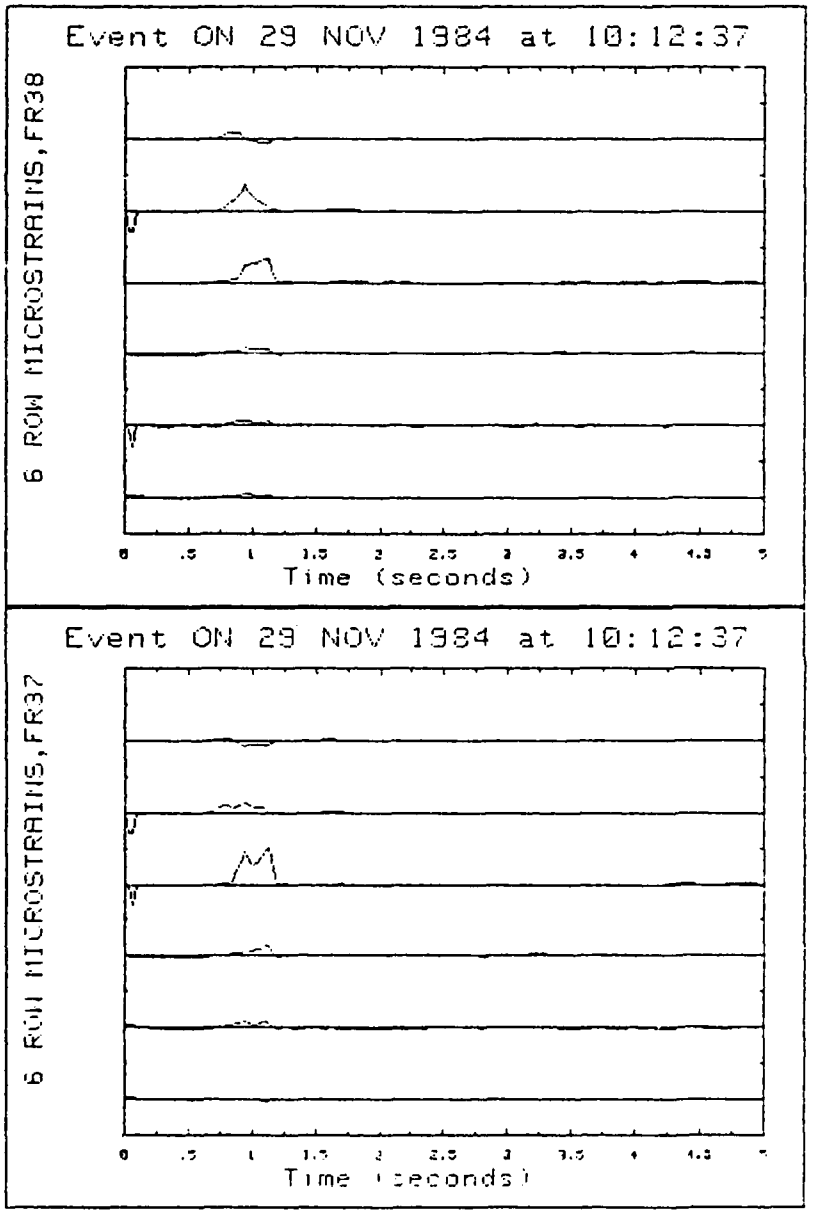

Event ON 29 NOV 1984 at 22:58:23
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 29 NOV 1984 at 22:58:23
Peak Pressure (psi)
Girth Along Frame (ft)

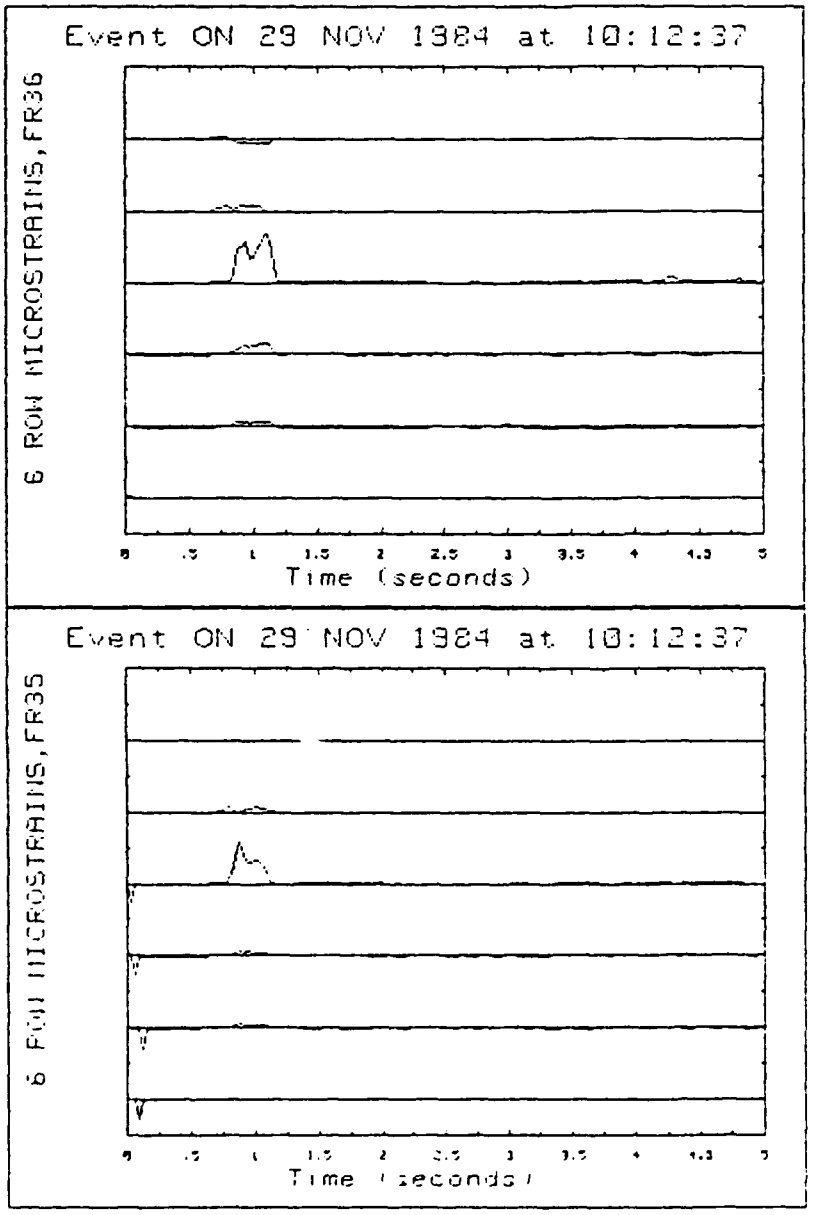

Event ON 29 NOV 1984 at 22:58:23
Velocity (knots)
Time (seconds)

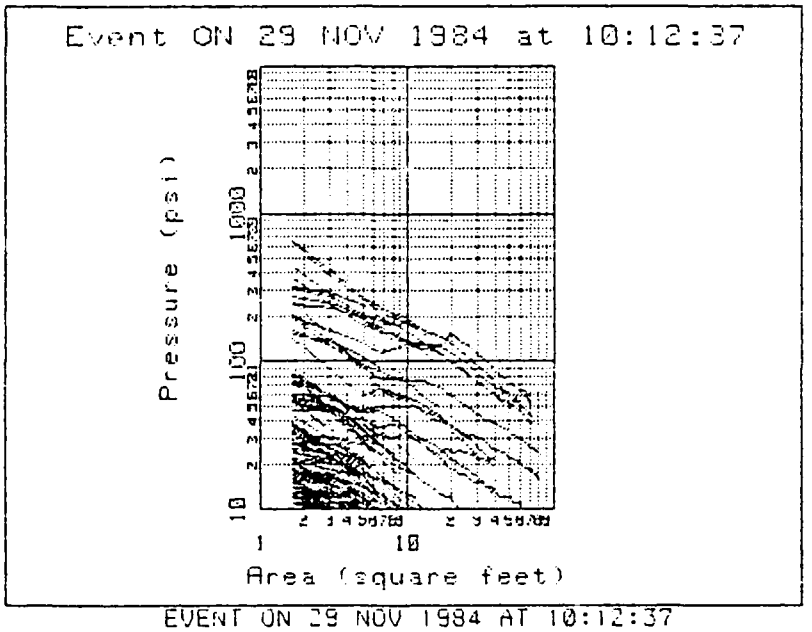

Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR44
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR43
Time (seconds)


Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR42
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR41
Time (seconds)


Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR40
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR39
Time (seconds)


Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR38
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR37
Time (seconds)


Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR36
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
6 ROW MICROSTRAINS,FR35
Time (seconds)



EVENT ON 29 NOV 1984 AT 10:12:37
TAPE NUMBER 3 ; TRACK NUMBER 1 ; FILE NUMBER 4
PEAK STRAIN 243 ; THRESHOLD 150
RELATIONSHIPS FOR TIME OF PEAK PRESSURE

MAX PRESSURE 666 PSI; TIME FRAME 33; REAL TIME 1.03
FRAME 40; ROW 4

AVERAGE PRESSURE (psi) vs AREA (square feet)

Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	666.00	391.00	273.00	235.00	207.00	202.00	179.00

Area	13.06	14.69	16.32
Pressure	160.00	150.00	137.00

PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

GIRTH	1.25	2.50
PRESSURE	666.00	348.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00
PRESSURE	666.00	391.00	273.00	214.00	89.00	86.00

RELATIONSHIPS FOR TIME OF PEAK FORCE

MAX TOTAL FORCE 262 LONG TONS; TIME FRAME 30; REAL TIME .94
FRAME 36; ROW 5

AVERAGE PRESSURE (psi) vs AREA (square feet)

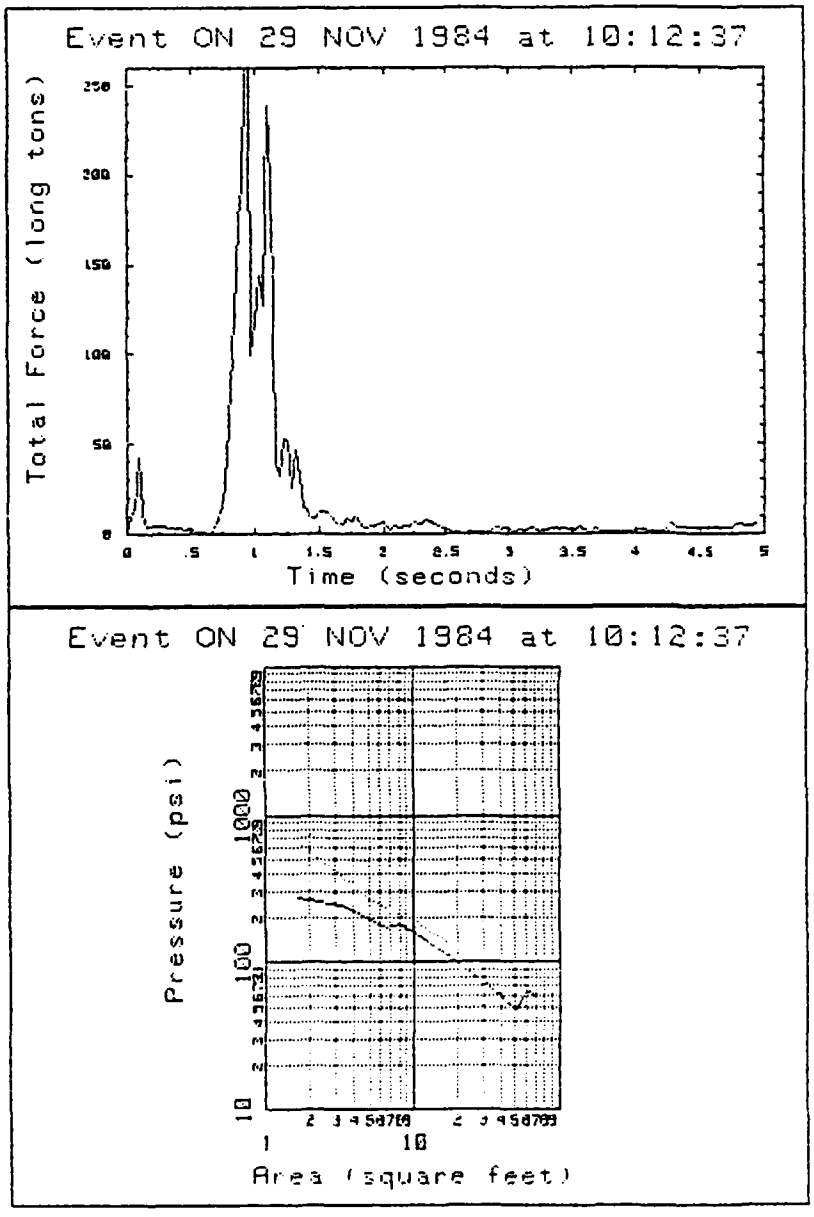
Area	1.63	3.26	4.90	6.53	8.16	9.79	11.42
Pressure	275.00	241.00	204.00	172.00	186.00	164.00	149.00
Area	13.06	14.69	16.32	17.95	19.58	21.22	22.85
Pressure	134.00	122.00	116.00	107.00	101.00	94.00	89.00
Area	24.48	26.11	27.74	29.38	31.01	32.64	34.27
Pressure	84.00	80.00	76.00	74.00	71.00	69.00	66.00
Area	35.90	37.53	39.17	40.80	42.43	44.06	45.69
Pressure	63.00	61.00	59.00	57.00	55.00	53.00	52.00
Area	47.33	48.96	50.59	52.22	53.85	55.49	57.12
Pressure	50.00	49.00	48.00	51.00	54.00	58.00	59.00
Area	58.75	60.38	62.01	63.65	65.28	66.91	68.54
Pressure	62.00	63.00	64.00	63.00	62.00	60.00	59.00
Area	70.17						
Pressure	58.00						

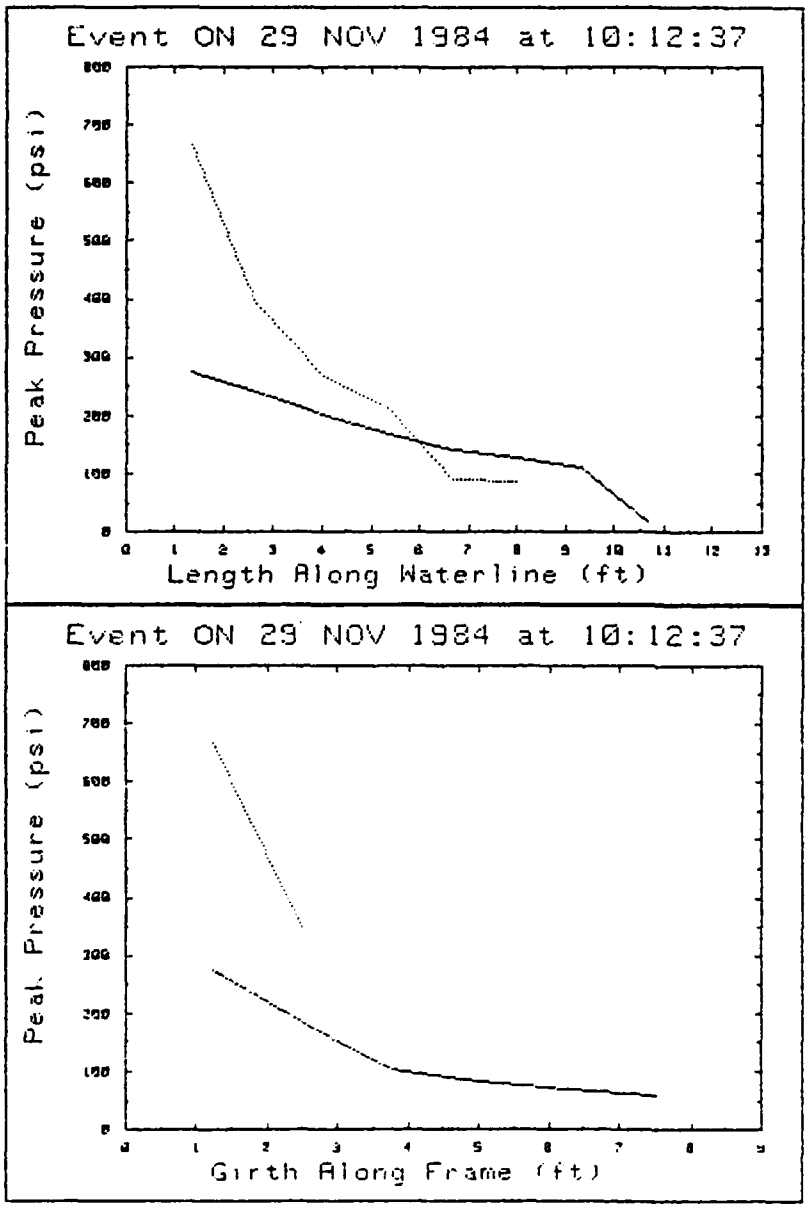
PRESSURE (PSI) VERSUS GIRTH ALONG FRAME (FT)

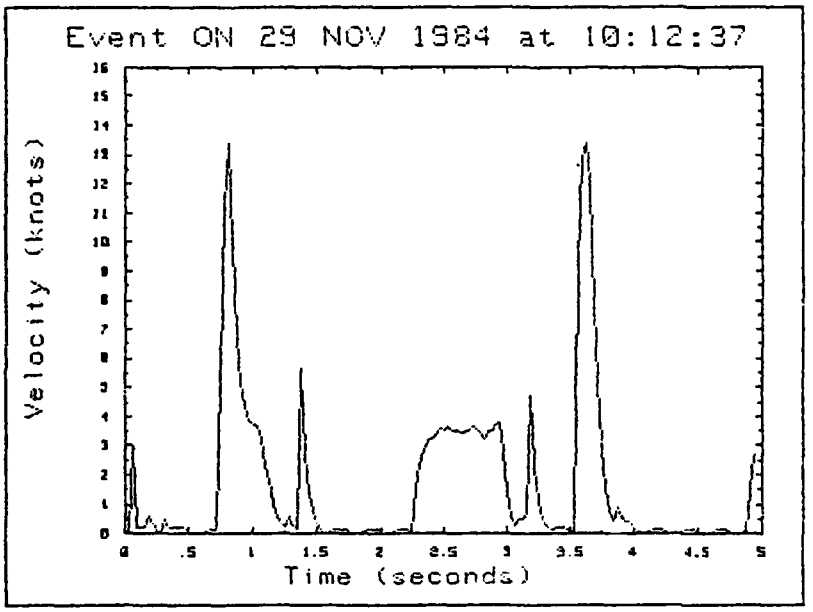
GIRTH	1.25	2.50	3.75	5.00	6.25	7.50
PRESSURE	275.00	184.00	105.00	82.00	70.00	60.00

PRESSURE (PSI) VERSUS LENGTH ALONG WATERLINE (FT)

LENGTH	1.33	2.67	4.00	5.33	6.67	8.00	9.33
PRESSURE	275.00	241.00	204.00	168.00	141.00	128.00	110.00
LENGTH	10.67						
PRESSURE	16.00						

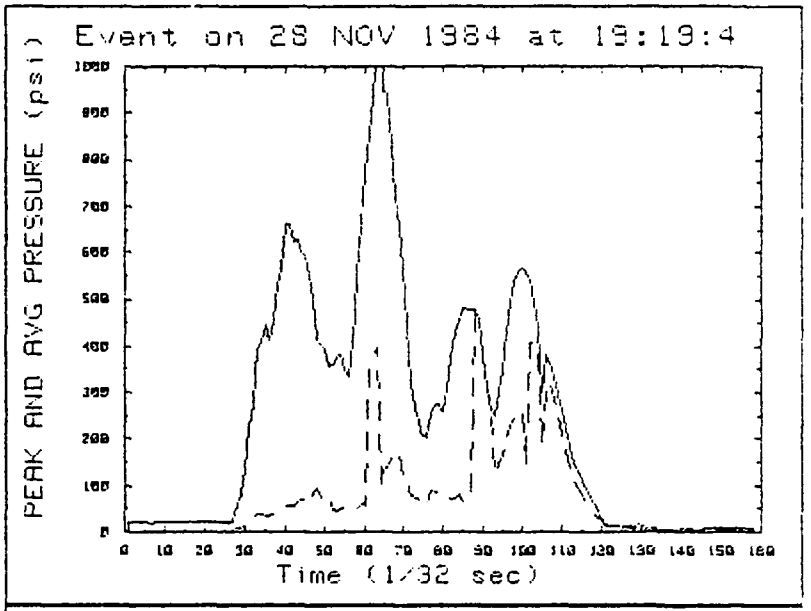

Event ON 29 NOV 1984 at 10:12:37
Total Force (long tons)
250
200
150
100
50
0
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (seconds)
Event ON 29 NOV 1984 at 10:12:37
Pressure (psi)
1000
100
10
1
10
Area (square feet)

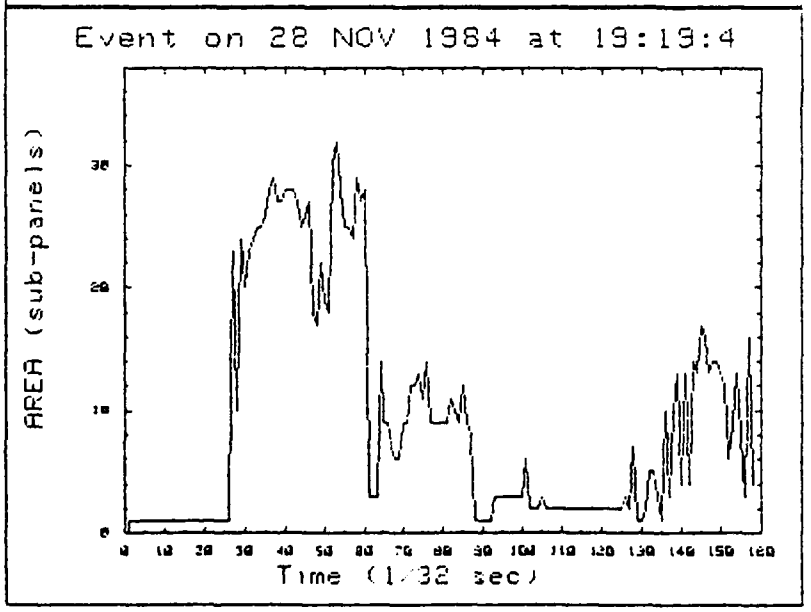

Event ON 29 NOV 1984 at 10:12:37
Peak Pressure (psi)
Length Along Waterline (ft)
Event ON 29 NOV 1984 at 10:12:37
Peak Pressure (psi)
Girth Along Frame (ft)

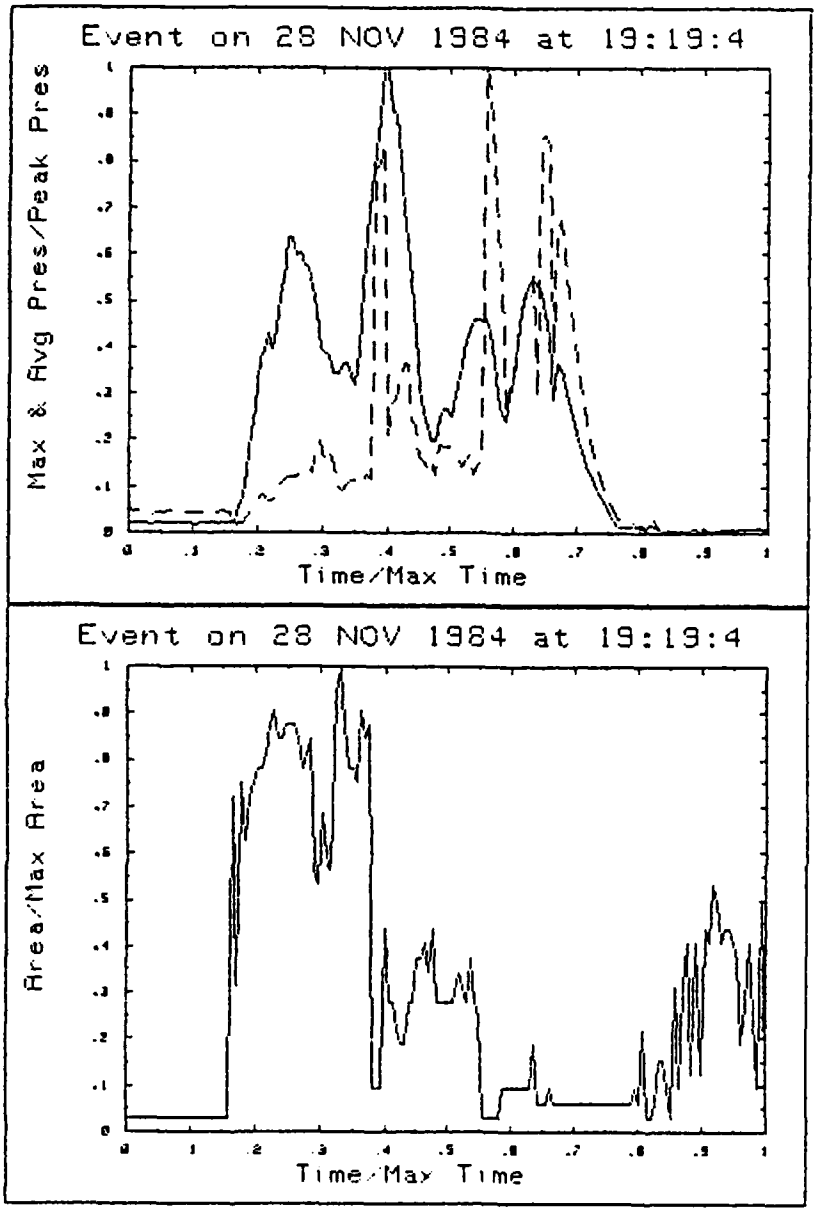

Event ON 29 NOV 1984 at 10:12:37
Velocity (knots)
Time (seconds)
0
.5
1
1.5
2
2.5
3
3.5
4
4.5
5

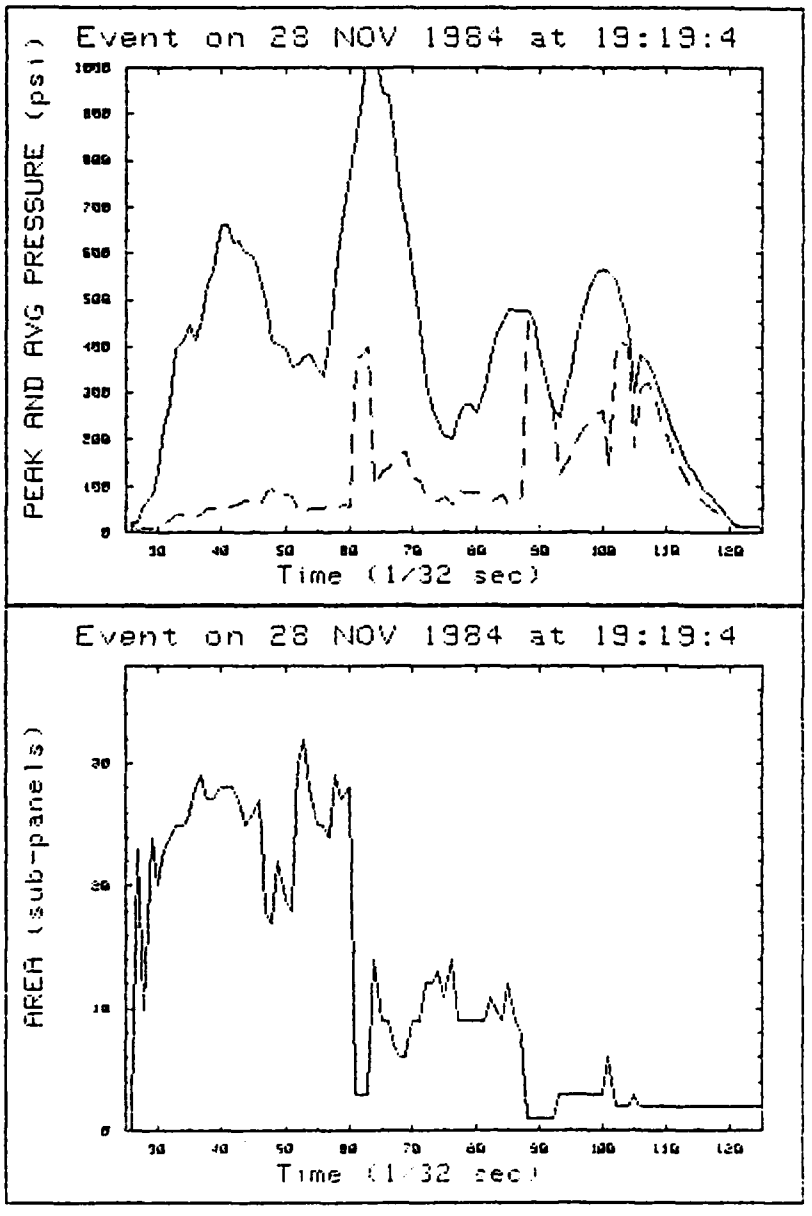
APPENDIX E

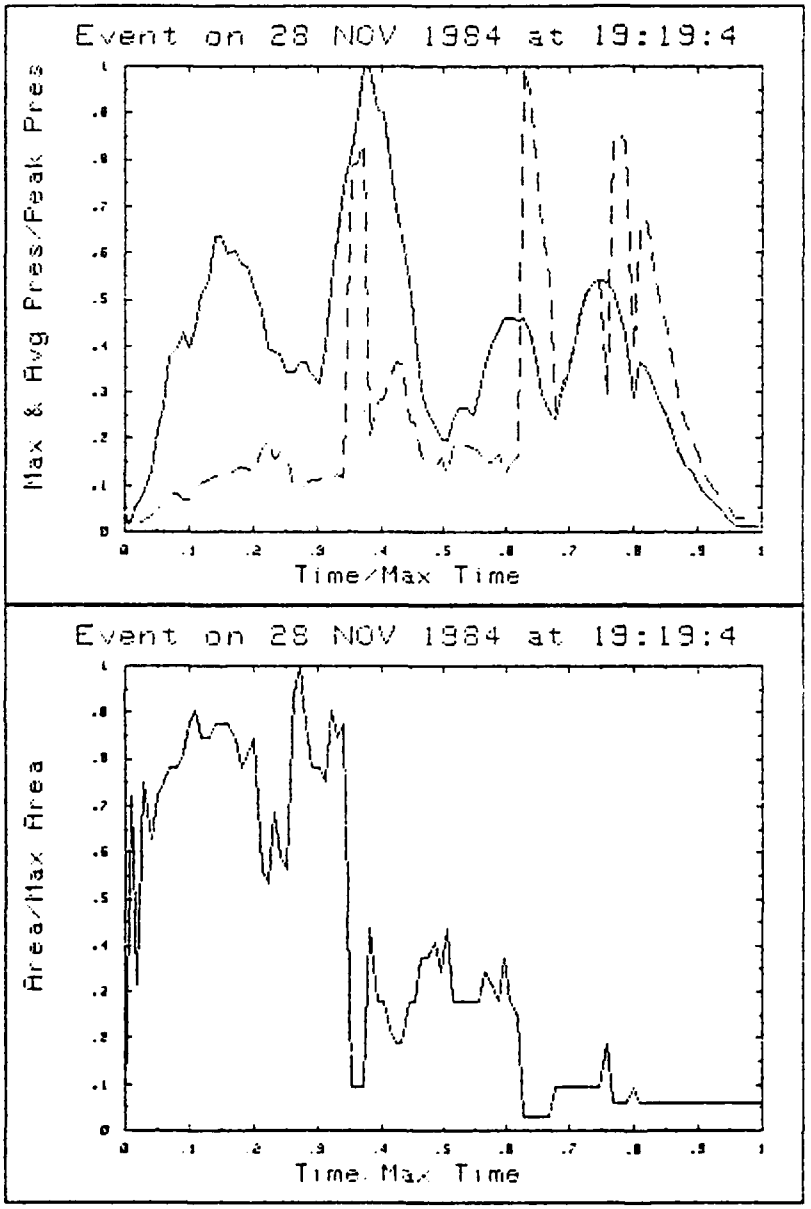
THREE EVENTS SHOWING THE TIME VARIATION OF PEAK AND AVERAGE PRESSURE AND CONTACT AREA

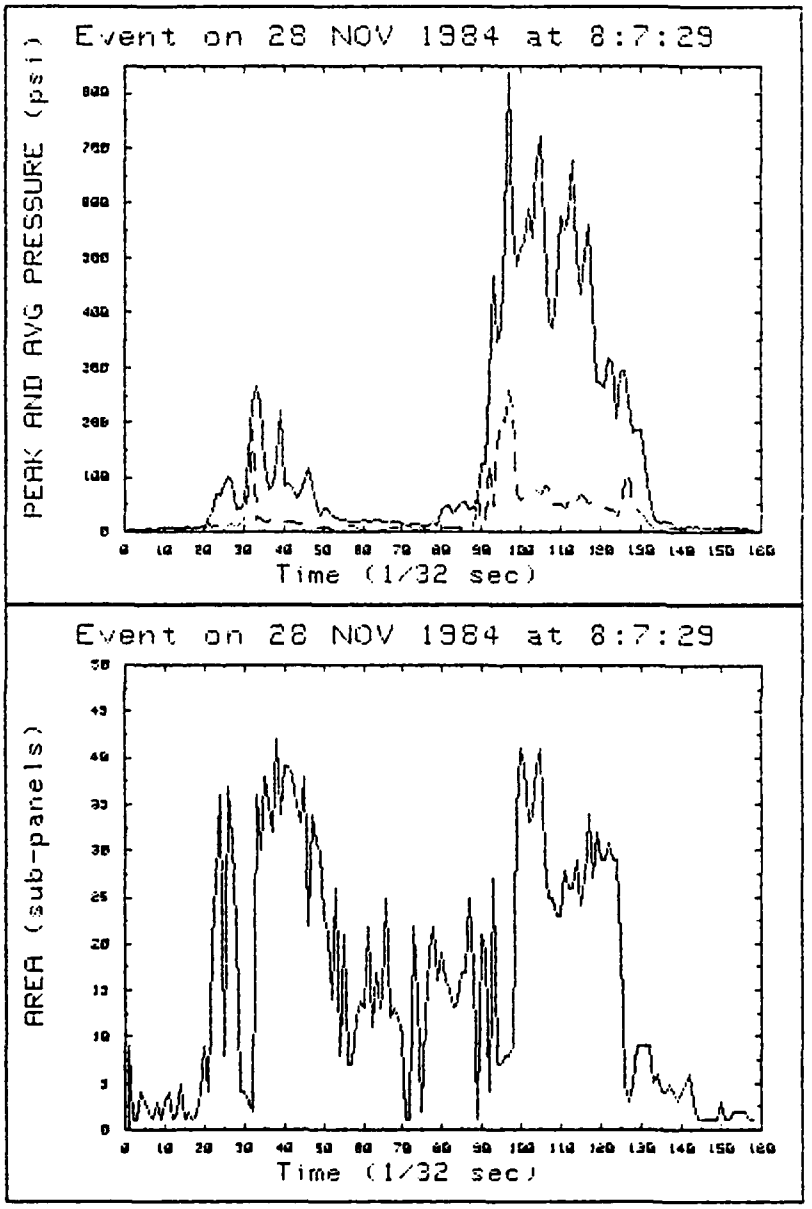


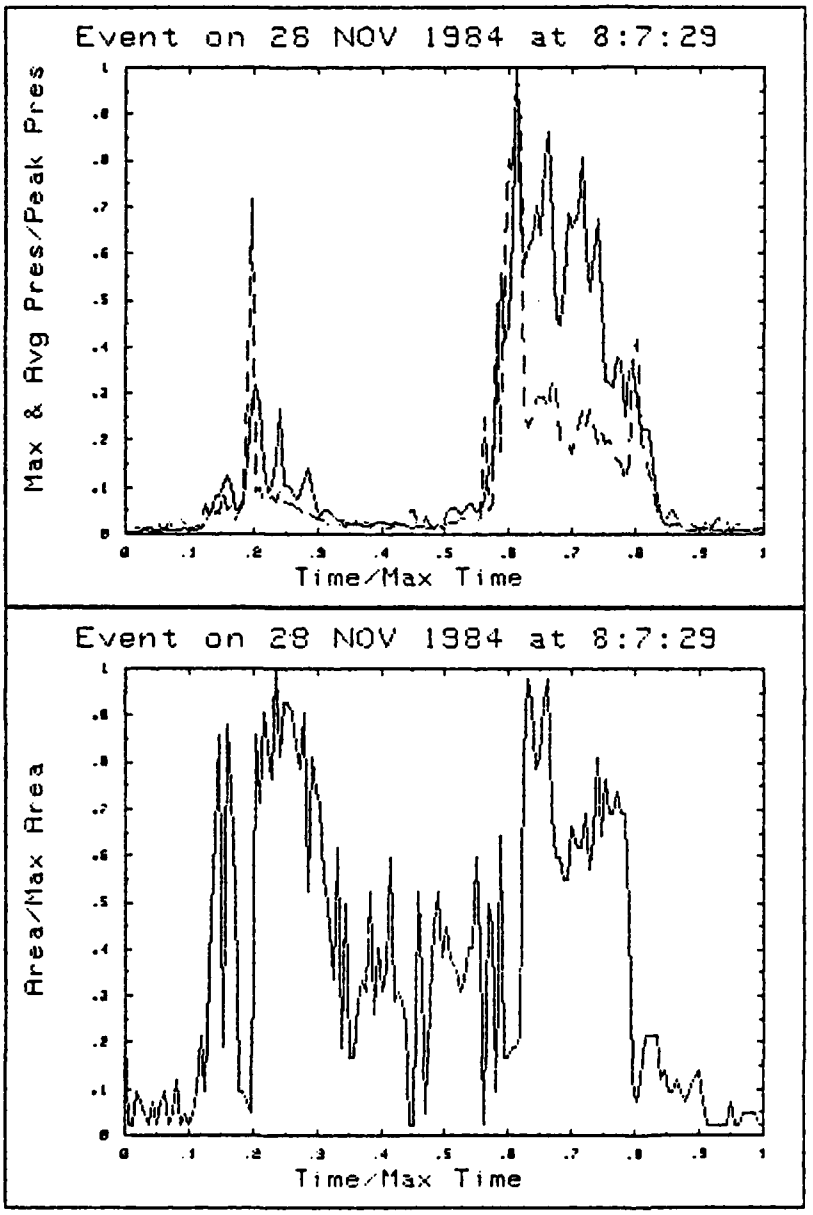


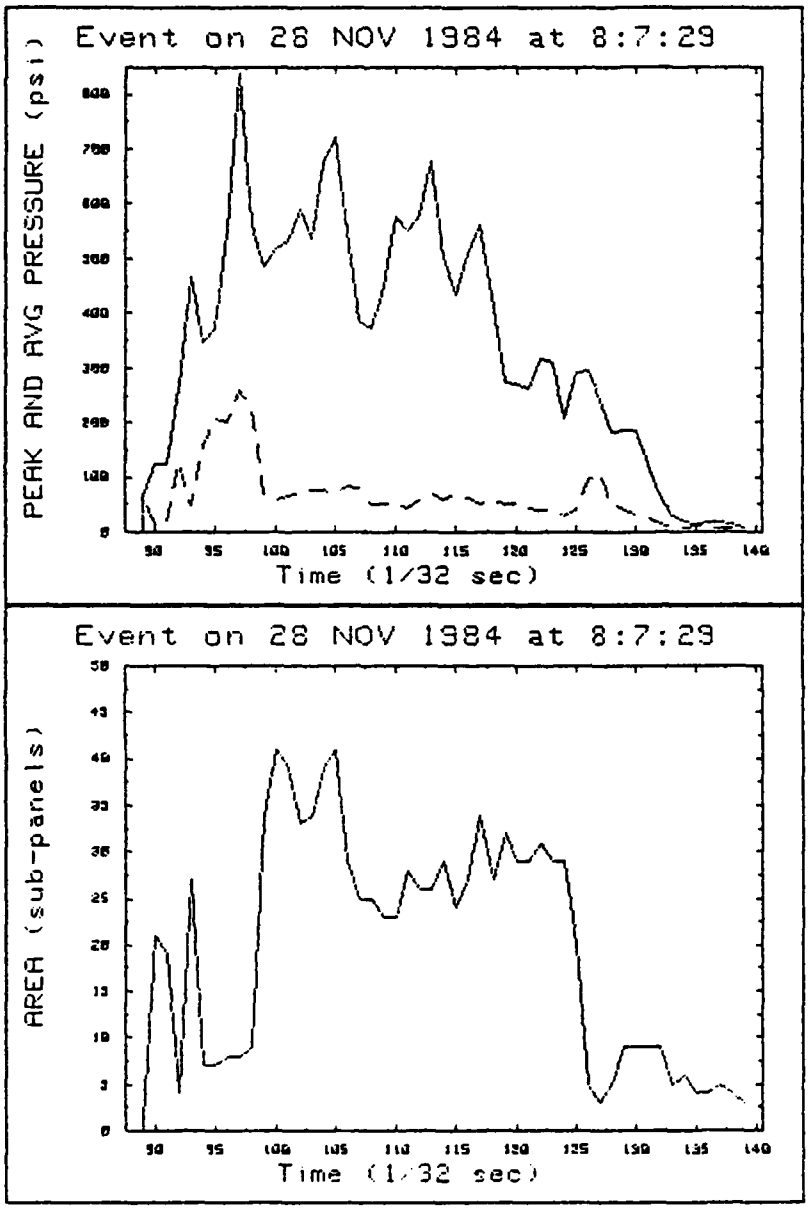

Event on 28 NOV 1984 at 19:19:4
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 28 NOV 1984 at 19:19:4
Area/Max Area
Time/Max Time

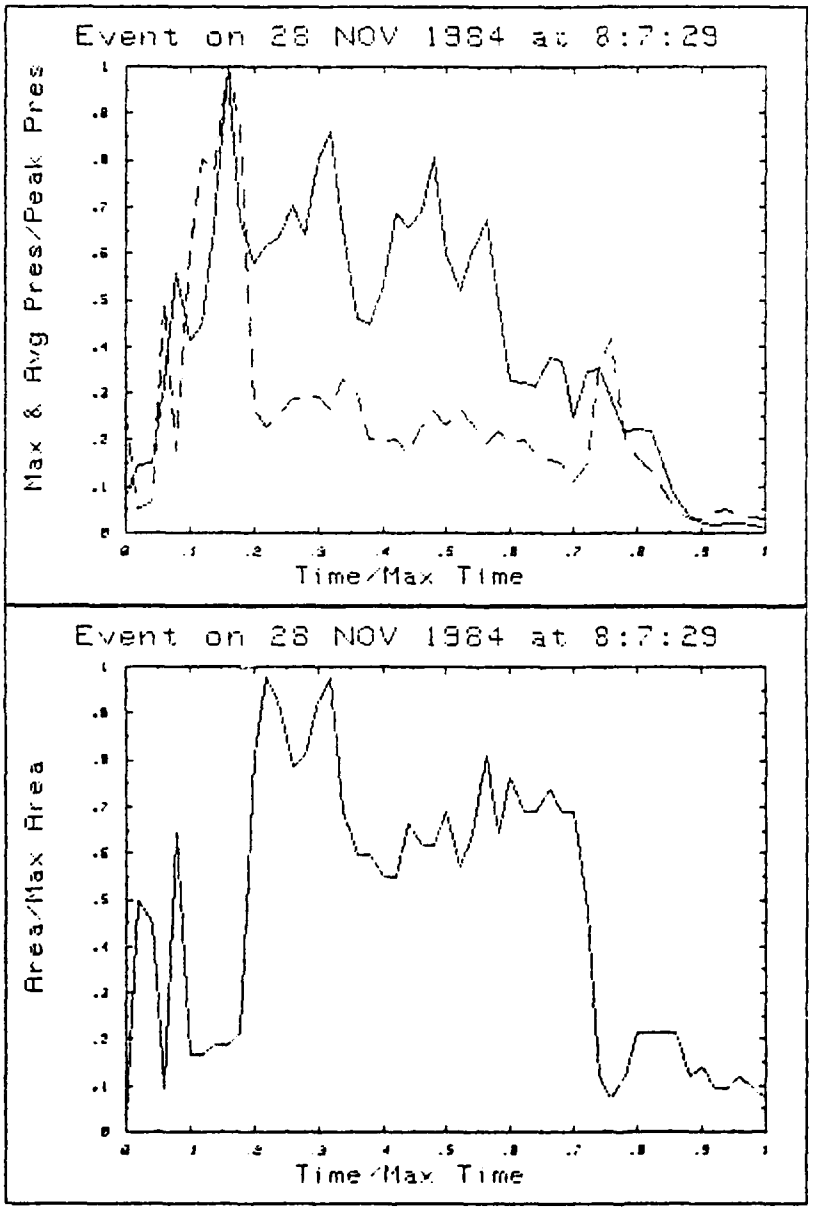

Event on 28 NOV 1984 at 19:19:4
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 28 NOV 1984 at 19:19:4
AREA (sub-panels)
Time (1/32 sec)

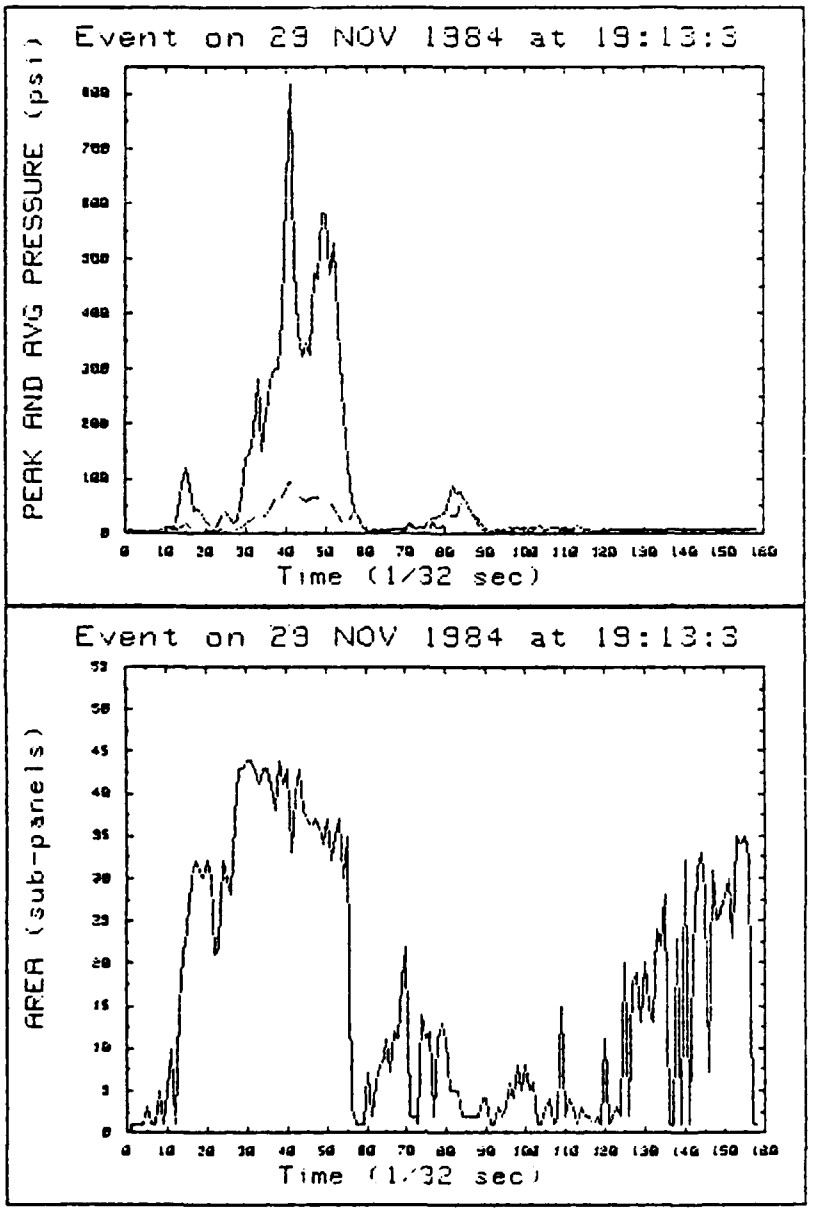

Event on 28 NOV 1984 at 19:19:4
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 28 NOV 1984 at 19:19:4
Area/Max Area
Time/Max Time

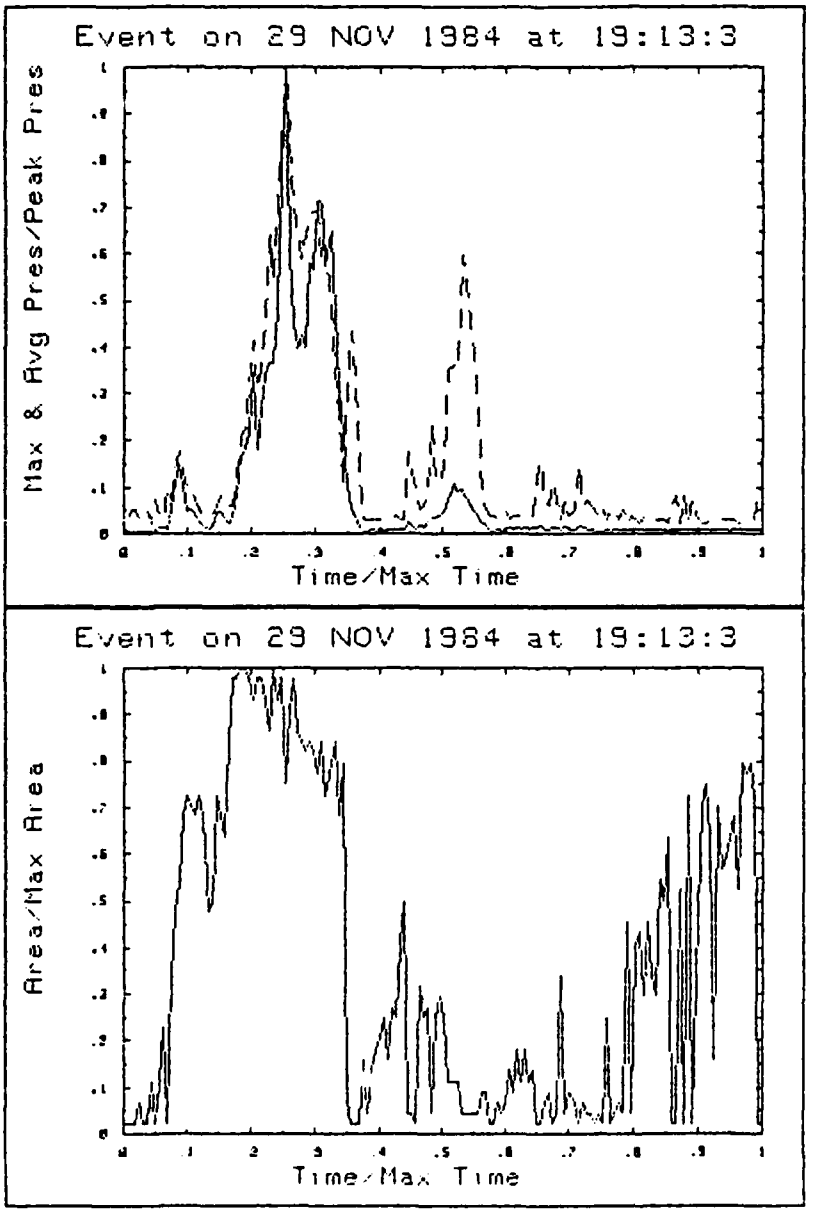

Event on 28 NOV 1984 at 8:7:29
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 28 NOV 1984 at 8:7:29
AREA (sub-panels)
Time (1/32 sec)

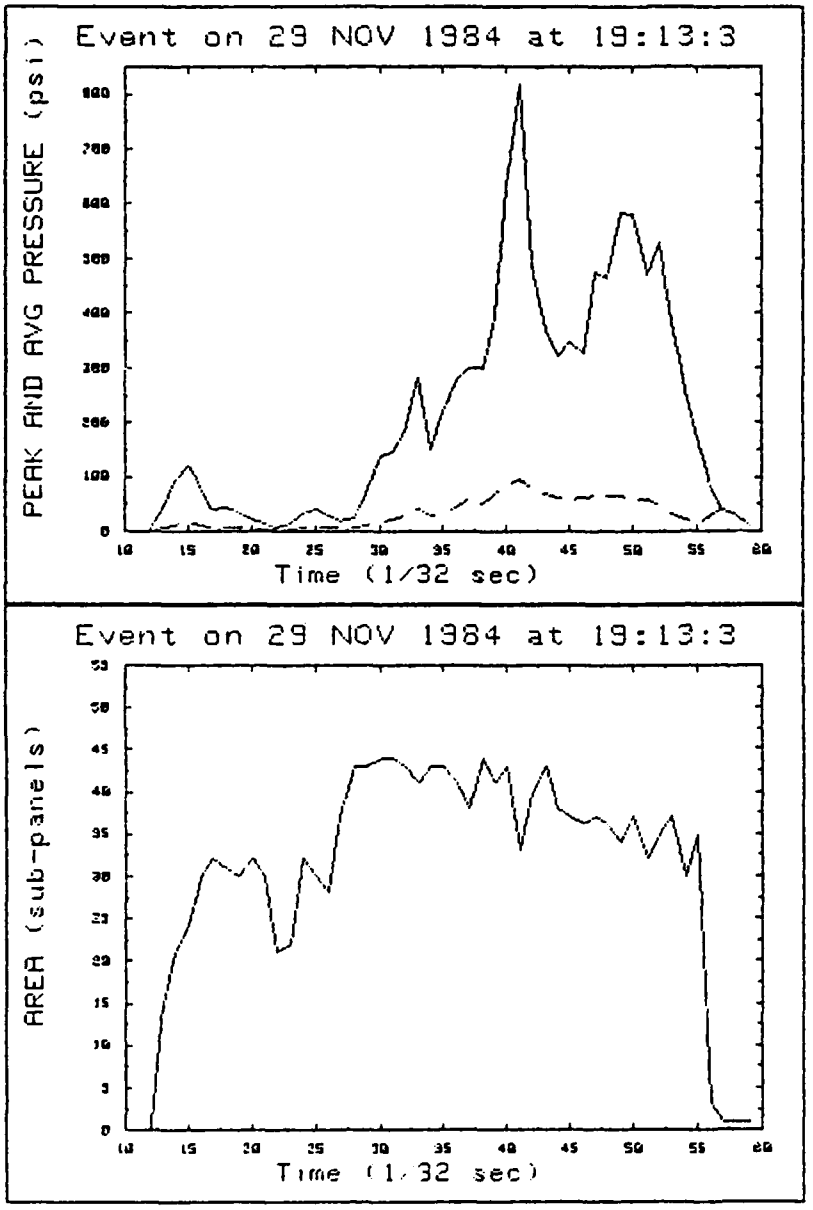

Event on 28 NOV 1984 at 8:7:29
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 28 NOV 1984 at 8:7:29
Area/Max Area
Time/Max Time

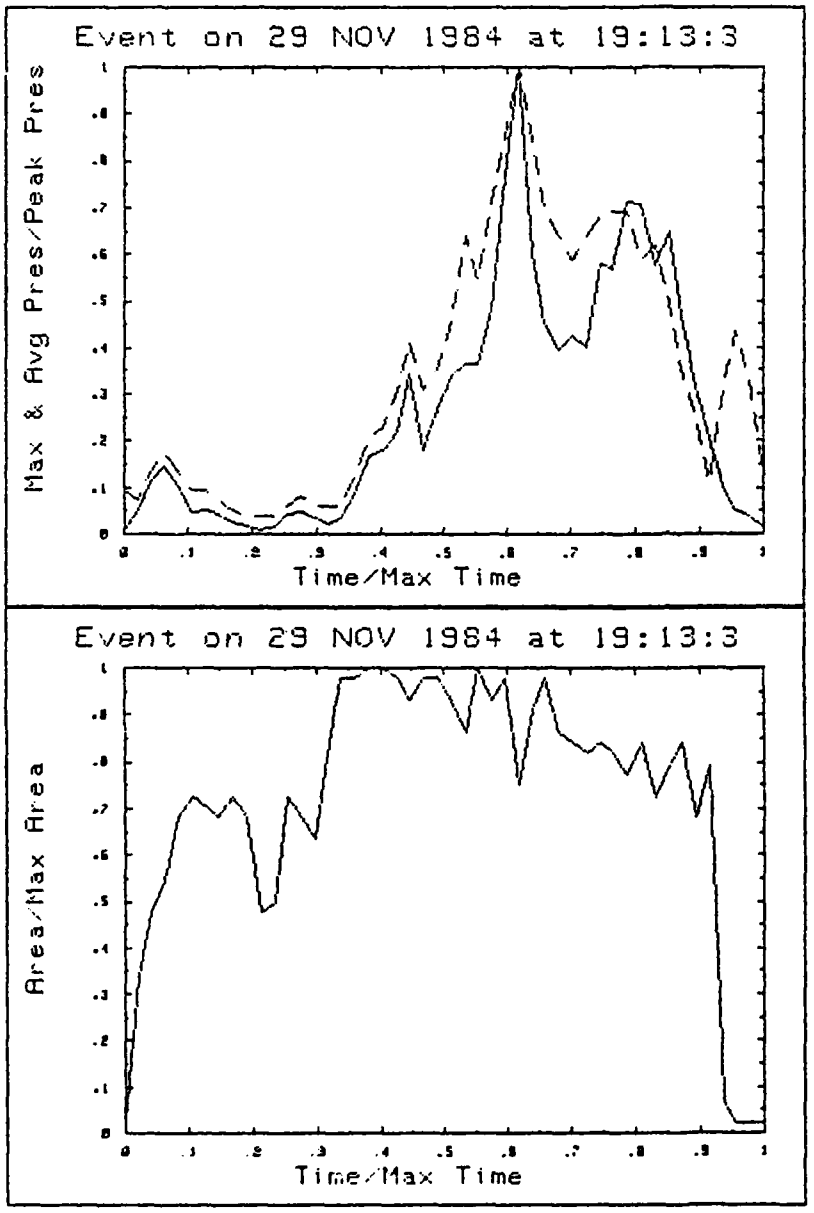

Event on 28 NOV 1984 at 8:7:29
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 28 NOV 1984 at 8:7:29
AREA (sub-panels)
Time (1/32 sec)


Event on 28 NOV 1984 at 8:7:29
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 28 NOV 1984 at 8:7:29
Area/Max Area
Time/Max Time


Event on 29 NOV 1984 at 19:13:3
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 29 NOV 1984 at 19:13:3
AREA (sub-panels)
Time (1/32 sec)


Event on 29 NOV 1984 at 19:13:3
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 29 NOV 1984 at 19:13:3
Area/Max Area
Time/Max Time


Event on 29 NOV 1984 at 19:13:3
PEAK AND AVG PRESSURE (psi)
Time (1/32 sec)
Event on 29 NOV 1984 at 19:13:3
AREA (sub-panels)
Time (1/32 sec)


Event on 29 NOV 1984 at 19:13:3
Max & Avg Pres/Peak Pres
Time/Max Time
Event on 29 NOV 1984 at 19:13:3
Area/Max Area
Time/Max Time

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